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EMERGENCY ESCAPE OF HANDICAPPED AIR TRAVELERS,(U)
JUL 77 J G BLETHROW, J D GARNER, D L LOWREY

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EMERGENCY ESCAPE OF HANDICAPPED AIR TRAVELERS

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July 1977

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16. Abstract

This report describes a study conducted by the Civil Aeromedical Institute to investigate potential problems related to the emergency evacuation of civil aircraft carrying handicapped passengers. The study includes an analysis of the movement of individual handicapped subjects in an aircraft cabin and the results of evacuation tests in which a portion of the test subjects either were handicapped or simulated handicaps. Data are given relative to assistance to handicapped passengers, the effects of groups of handicapped passengers, seating location, floor slope, and exit type on the evacuation time. Suggestions by handicapped subjects and a summary of recent aircraft accidents involving evacuation of handicapped passengers are included as appendices to the report.

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INTRODUCTION

The increasing mobility of handicapped individuals has created a growing recognition of the problems they encounter in traveling. In air travel, there is a need for equitable and consistent treatment of these passengers without compromise of safety for all passengers. The Federal Aviation Act of 1958 states that "no air carrier . . . shall . . . subject any particular person . . . to any unjust discrimination or any undue or unreasonable prejudice or disadvantage in any respect whatsoever,"[1] but that "any air carrier is authorized to refuse transportation to a passenger . . . when, in the opinion of the air carrier, such transportation would or might be inimical to safety of flight."[1]

In 1962 the Air Traffic Conference of America (ATCA) submitted to the Civil Aeronautics Board (CAB) its criteria for the transportation of handicapped passengers.[2] These criteria outlined the types of passengers and cargo that were acceptable for air transport and established standards to expedite the transport of certain handicapped individuals and to disqualify from travel by air those who could not care for themselves. These criteria were accepted and approved by the CAB in Order E-19154, December 31, 1962.

A reevaluation was stimulated by complaints from both handicapped individuals and organizations representing them. The complaints involved most [illegible] carriers and alleged inequitable and unjust treatment.

On July 28, 1972, a letter from the CAB to the Secretary of Transportation emphasized the nonuniform interpretation and application of rules governing the carriage of physically handicapped persons and the absence of definitive safety standards. In response to this letter, the Federal Aviation Administration (FAA) recommended that action be initiated to promulgate regulations relating to:

a. Defining the types of physically disabled passengers who could travel by air without undue impairment of overall passenger safety.

b. The number of unaccompanied nonambulatory passengers that could be accommodated safely on an aircraft.

c. Emergency evacuation provisions for handicapped passengers.

d. Provisions for medication or continual assistance during flight.

e. Personal oxygen supplies required by the traveler.

In late 1972, personnel from the FAA Flight Standards Service and the Office of Aviation Medicine met to establish procedures for implementing those recommendations and formulated a requirement for an emergency evacuation test program to obtain data on evacuation problems associated with handicapped

travelers. Civil Aeromedical Institute (CAMI) and Flight Standards personnel met in March 1973 to develop the test program.

METHOD AND RESULTS

The test facility used in these studies was the evacuation simulator at CAMI. This simulator consists of a C-124 fuselage section, 12 ft wide and 77 ft long, mounted on a hydraulically controlled platform (Figure 1).

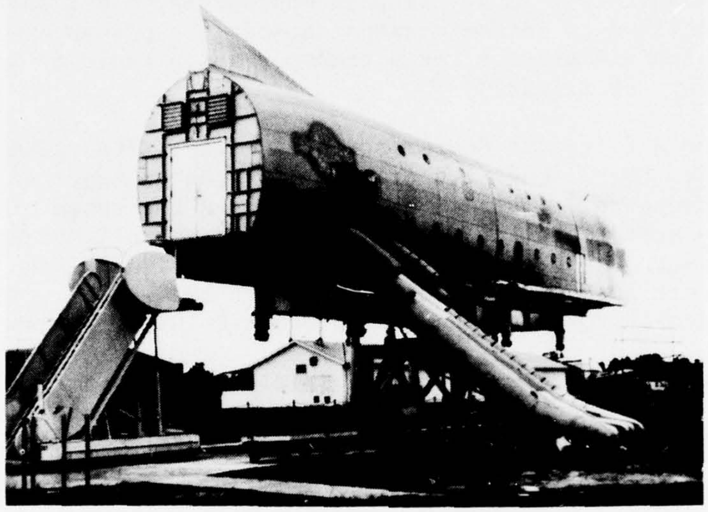

Figure 1. The evacuation simulator positioned at a 16-ft floor-level height, similar to a wide-body-transport height in a wheels-down, level condition.

The simulator can lift the fuselage up to 16 ft, pitch up to 20^{o} fore or aft, and roll up to 20^{o} right or left, or combine these movements (Figure 2).

The interior of the simulator provides a six-abreast tourist-class seating configuration with a 15-in-wide center aisle. The seating capacity and width approximate those of a B-727 tourist-class cabin (Figure 3). The left rear exit, 32 in wide and 72 in high, is reached through a cross aisle 33 in wide. In addition to this exit, the simulator has a floor-level door exit (24 in wide and 48 in high) and two overwing hatch exits (20 in wide and 36 in high) as shown in Figure 4. Inflatable slides used in the studies included a 23-ft-long, 3-ft-wide single-lane slide; a 24-ft-long, 7½-ft-wide double-lane slide; and a 28-ft-10-in-long, 8-ft-wide double-lane slide. The slides were inflated before the test and attached to the cabin floor by a girt bar/door clip system. Safety nets were placed under the slides.

Subjects were recruited from several sources. Nonhandicapped subjects were FAA employees or were hired through the University of Oklahoma Office of

Research Administration. Most handicapped subjects were recruited through participating organizations (see acknowledgments).

Figure 2. The evacuation simulator positioned 12^{o} nose down and in a 12^{o} left roll as in an emergency landing with nose gear and left main gear failure.

Figure 3. Seating configuration of the evacuation simulator.

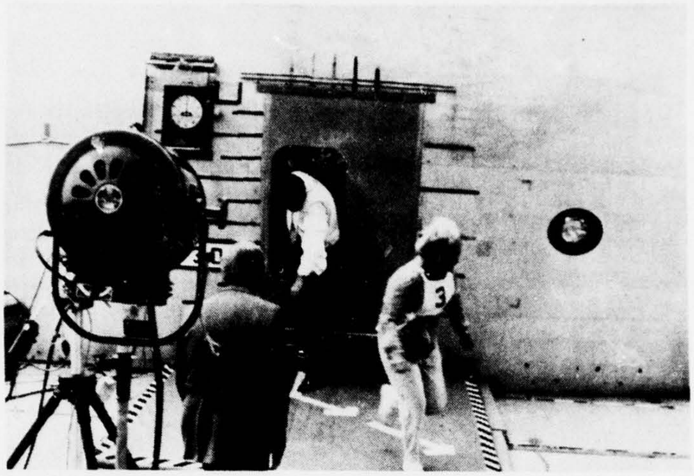

Figure 4. Overwing exit with normal stepdown distance to the wing surface.

Testing was conducted under good visual conditions for the safety of the subjects and to allow observations for time and motion analyses.

For reasons of safety, handicapped subjects did not usually participate in group evacuations or tests in which escape slides were employed. Only one paraplegic subject, included in a passenger load of 30, was allowed to enter the passenger flow.

In most group tests, nonhandicapped subjects simulated various handicaps; e.g., whole body (arthritis, etc.), upper limb and lower limb impairment. Anthropomorphic dummies were used to simulate nonambulatory passengers.

Individual Handicap Evaluation. Each subject was interviewed before testing to establish the extent of the handicap and to lessen any possible anxiety on the part of the subject. The experimental tasks were described to the subject and the purpose for the studies was explained with emphasis on performing as quickly as possible to simulate an emergency escape. During these tests, the subject moved from one of three designated seat locations to a specific exit. The three seat locations (Figure 5) presented different escape paths, distances, and aisle/accessway restrictions. Rest periods were provided when necessary.

Seat 1 (Figure 5) was the aisle seat of the left rear exit row. The subject sat with his seatbelt fastened and his arms on the armrests. On signal, the subject released the seatbelt and moved a distance of 4 ft 9 in to the door, touching the door to complete the test.

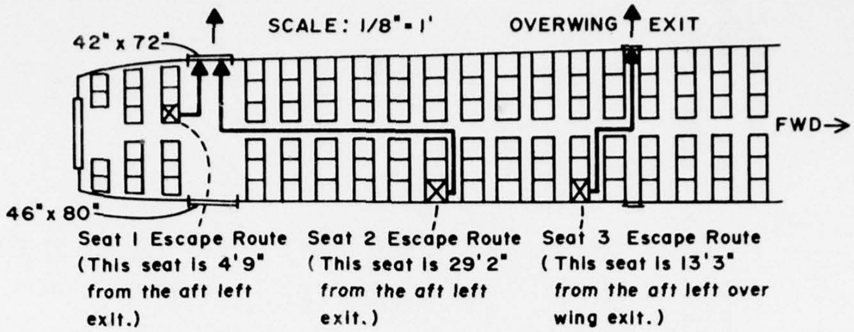

Figure 5. Escape routes from three seat locations in the evacuation simulator.

During these tests, it was noted that subjects with hemiplegia or severe cerebral palsy and only one functioning arm needed seat backs to support them while standing. Since the occupant of Seat 1 was in the exit accessway upon standing and the forward seat backs were beyond normal reach, these subjects had difficulty in standing.

Paraplegics lowered themselves to the floor while holding the armrest, or merely fell to the floor, and then crawled to the exit. Had the test continued onto an escape slide, these subjects would have been required to turn around to avoid entering the slide headfirst. Other subjects used the armrests to stand and then moved directly to the exit. Results of these tests are shown in Table 1.

Seat 2 (Figure 5) is a right window seat, 29 ft 2 in from the left rear exit. The Seat 2 escape route included a 5-ft distance from the window seat to the aisle and provided a seat row clearance of 12 in with a 34-in seat-pitch configuration. Once in the aisle, the subject moved 18 ft down the center aisle, turned to the exit accessway, then moved 6 ft to the exit. This route represents the longest distance to an exit in modern transport aircraft. Times to complete this escape route are shown in Table 2.

Most participants used the forward seat backs for support. Some subjects with lower limb impairments used the armrests to turn around and provide support as they moved into and down the aisle. Paraplegics usually approached the exit by holding the armrests and easing themselves to the floor between seats, then pushing themselves backward toward the exit with their arms. One female and one male paraplegic subject did not complete the Seat 2 escape route. The male paraplegic, because of his size (210 lb), found that he must move sideways down the aisle. He became exhausted after moving past three rows of seats. In one trial a 220-lb, 21-yr-old female subject walked on her knees, holding onto the armrests, and averaged 1.01 ft/s. In her second trial she moved on her hands and knees in the aisle between armrests at a rate of 1.67 ft/s. This subject normally used crutches but found them awkward and difficult to use in the cabin aisle. A 53-yr-old male subject who had a

TABLE 1. Time Required to Move From Seat 1 to the Exit

Impairment or Cause of Impairment	Number of Subjects	Total Time (s)	SD* (s)	Range (s)	Percent Over Unimpaired Mean Time
Neurological					
Blindness	21	2.93	1.98	1.05 - 10.00	50
Deafness	5	3.34	1.61	1.19 - 5.50	71
Mental Deficiency	19	4.32	1.38	2.23 - 7.70	122
Neuromuscular					
Cerebral Palsy	8	10.00	7.16	1.60 - 21.55	413
Old Age	10	4.31	1.51	1.12 - 6.00	121
Paraplegia and Quadriplegia	9	7.80	5.26	3.50 - 20.55	300
Hemiplegia	10	9.94	5.16	3.00 - 19.70	410
Muscular Dystrophy, Multiple Sclerosis, and Polio	7	6.00	2.91	2.76 - 10.36	208
Orthopedic					
Arthritis	5	4.36	2.04	1.40 - 7.00	124
Arm Cast	2	2.38	0.18	2.25 - 2.50	22
Lower Leg Cast and Amputee	3	4.25	1.23	3.03 - 5.48	118
Congenital Birth Defects	5	4.60	1.19	3.25 - 6.00	136
Other					
Obesity	9	3.98	1.46	1.70 - 7.05	104
Unimpaired	22	1.95	0.51	1.30 - 3.80	0

*Standard Deviation

TABLE 2. Time Required to Move From Seat 2 to the Exit

Impairment or Cause of Impairment	Number of Subjects	Total Time (s)	SD (s)	Range (s)	Percent Over Unimpaired Mean Time
Neurological					
Blindness	21	12.82	8.47	6.33 - 47.00	114
Deafness	5	11.53	2.95	7.64 - 15.12	92
Mental Deficiency	20	13.26	5.40	7.00 - 31.00	121
Neuromuscular					
Cerebral Palsy	8	38.54	25.64	9.50 - 67.75	542
Old Age	10	13.69	4.86	6.66 - 22.00	128
Paraplegia and Quadriplegia	18	28.65	12.64	12.70 - 59.75	378
Hemiplegia	11	77.32	78.55	18.00 -274.12	1,189
Muscular Dystrophy, Multiple Sclerosis, and Polio	7	22.59	14.72	6.61 - 53.00	277
Orthopedic					
Arthritis	5	13.51	3.04	6.00 - 12.75	125
Arm Cast	2	7.45	0.64	7.00 - 7.90	24
Lower Leg Cast and Amputee	3	14.76	3.88	10.77 - 18.52	146
Congenital Birth Defects	5	15.33	6.36	9.28 - 24.78	156
Other					
Obesity	9	13.05	3.58	7.65 - 17.97	118
Unimpaired	22	6.00	1.80	4.18 - 11.78	0

loss of neuromuscular control in both legs and wore leg braces, walked upright down the aisle by holding to seat backs and achieved a rate of 1.54 ft/s. Using his crutches, he attained a rate of 1.06 ft/s. A 26-yr-old male subject walked upright with the aid of seat backs at a rate of 2.48 ft/s and crawled backward in the aisle at a rate of 2.01 ft/s. Blind subjects indicated that they used the interrupted seat spacings to tell when they had reached exit accessways while moving down the aisle. Few made a point of counting or remembering numbers of seat rows to exits. Two hemiplegic subjects, paralyzed on their right sides, had difficulty turning right into the exit accessway. One could not make the turn when seat back support on his left (good) side became out of reach, but he felt that he could have turned to the left. Other hemiplegics stated they could move better sideways when their good legs were toward the direction of movement. Four mentally impaired subjects became distracted by objects and friends in the cabin, or could not remember instructions, and thus had difficulty completing the test. One of these subjects traveled halfway to the exit, then sat down as though the test were completed. Obese subjects generally moved at acceptable rates. There were three instances in which the seatbelt buckle was covered by abdominal fat folds. Statements from five obese subjects indicated that the seat space between armrests wedged them into the seat and added to the effort required to stand; thus, some obese passengers may have to be helped out of their seats in an emergency. These subjects had little difficulty moving down the aisle but were delayed getting into the aisle from window seats; they used approximately 43 percent of the total time moving to the aisle, a distance that comprises only 17 percent of the escape route.

Comparative tests were accomplished with the subjects seated in the aisle seat of the seat row containing Seat 2, the window seat. In general, subjects sitting in the window seat took 50 percent more time to reach the exit than did those sitting in the aisle seat (Table 3). Paralytic subjects demonstrated the greatest delay.

The times of all handicapped subjects who moved from Seat 2 to the left rear exit are shown in Figure 6. For the data in this figure, an individual normally requiring a wheelchair was considered nonambulatory and all others were considered ambulatory.

Table 4 shows the rate of movement along the straight 18-ft aisle. Data from unimpaired subjects are included for comparison.

The Seat 3 location (Figure 5) required subjects to move across the cabin to an overwing exit one row forward and on the opposite side of the fuselage. This route was used to obtain data for movement between seats. Subjects moved a distance of 13 ft 3 in, of which 10 ft 10 in was in seat rows. Results of these tests are shown in Table 5.

The subjects again used armrests and seat backs to assist their movement. Subjects who could stand upright moved sideways in the seat rows. Hemiplegics found it difficult to move in the direction of the paralyzed side. Paraplegics lowered themselves to the floor and then moved between the seat rows.

TABLE 3. Comparison of Effects of Aisle and Window Seat Locations

Handicap Category	Number of Subjects	Average Times to Reach the Exit (s)		Average Times to Reach the Aisle (s)		Average Percent of the Total Escape Times Used to Get to the Aisle	
		From Window Seat	From Aisle Seat	From Window Seat	From Aisle Seat	From Window Seat	From Aisle Seat
Blind	15	10.94	7.99	4.24	1.29	39	16
Mental Deficiency	15	14.33	9.72	6.63	2.02	46	21
Deaf	2	10.70	7.68	4.35	1.33	41	17
Cerebral Palsy	3	27.85	20.21	11.00	3.36	39	17
Elderly	8	12.29	8.29	5.76	1.76	47	21
Hemiplegia	10	50.91	40.97	14.30	4.36	28	11
Multiple Sclerosis	2	36.65	25.88	15.50	4.73	42	18
Muscular Dystrophy	1	6.61	4.39	3.20	0.98	48	22
Paraplegia	12	31.27	24.23	10.13	3.09	32	13
Polio	1	23.25	16.30	10.00	3.05	43	19
Arthritis	5	14.08	9.92	5.98	1.82	42	18
Cast--Upper Arm	2	7.45	4.91	3.65	1.11	49	23
Deformity	3	14.69	10.82	5.56	1.70	38	16
Leg Prosthesis	2	14.65	9.82	6.95	2.12	47	22
Obesity	5	13.91	9.73	6.02	1.84	43	19

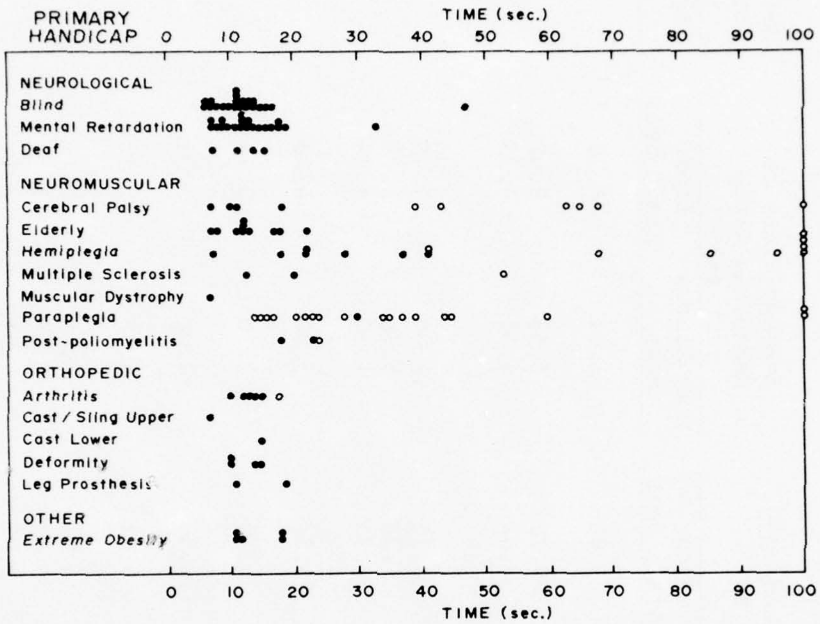

Figure 6. Total times for 126 handicapped subjects to reach the aft left exit from the Seat 2 position over a 29-ft 2-in distance. Solid circles represent ambulatory subjects who usually move with or without aids. Open circles represent nonambulatory subjects who usually require wheelchairs for mobility.

TABLE 4. Rate of Movement Through the Aisle

Impairment or Cause of Impairment	Number of Subjects	Average Rate of Movement (ft/s)	Range (ft/s)
Neurological			
Blindness	21	3.29	0.60 - 5.79
Deafness	5	4.65	1.49 - 8.21
Mental Deficiency	21	3.68	1.29 - 8.37
Neuromuscular			
Cerebral Palsy	7	1.59	0.42 - 5.49
Old Age	10	3.59	1.30 - 5.27
Paraplegia and Quadriplegia	20	1.58	0.70 - 4.18
Hemiplegia	14	1.00	0.20 - 2.61
Muscular Dystrophy, Multiple Sclerosis, and Polio	7	2.42	0.78 - 7.29
Orthopedic			
Arthritis	5	3.02	2.28 - 4.29
Arm Cast	2	6.25	5.60 - 6.89
Lower Leg Cast and Amputee	3	2.38	1.89 - 2.95
Congenital Birth Defects	5	2.81	1.40 - 4.65
Other			
Obesity	9	3.91	1.89 - 8.37
Unimpaired	24	8.01	3.00 - 10.05

TABLE 5. Time Required to Move From Seat 3 to the Exit

Impairment or Cause of Impairment	Number of Subjects	Mean Times (s)	SD (s)	Range (s)	Percent Over Unimpaired Mean Time
Neurological					
Blindness	21	7.01	4.46	3.07 - 22.50	87
Deafness	5	7.17	1.11	5.94 - 8.50	91
Mental Deficiency	20	7.62	2.74	4.25 - 16.59	103
Neuromuscular					
Cerebral Palsy	8	20.75	11.78	7.47 - 50.00	453
Old Age	10	8.37	2.64	3.87 - 11.95	123
Paraplegia and Quadriplegia	7	17.42	5.73	8.50 - 25.50	365
Hemiplegia	11	34.76	30.04	9.96 - 113.30	827
Muscular Dystrophy, Multiple Sclerosis, and Polio	7	13.96	9.69	5.47 - 33.53	272
Orthopedic					
Arthritis	5	9.01	3.19	6.00 - 12.75	140
Arm Cast	2	4.63	0.61	4.20 - 5.06	23
Lower Leg Cast and Amputee	3	8.30	4.03	5.50 - 12.92	121
Congenital Birth Defects	5	8.27	2.73	6.00 - 12.19	121
Other					
Obesity	9	8.61	3.55	4.20 - 14.52	130
Unimpaired	22	3.75	0.99	2.00 - 6.90	0

Tests were also conducted to evaluate the effects of aircraft floor slope simulating a nose gear and right main gear failure (a floor angle of 5^o nose down and 5^o right roll). Subjects moved unassisted from Seat 2 to the left rear exit while the fuselage was thus oriented. These rates of movement are compared to rates in the level condition in Table 6. Subjects with the highest rate of movement in the level condition showed the greatest decrement in performance when the floor was sloped. Two subjects repeated the test with the fuselage oriented in the 5^o left roll and 5^o nose down position with no apparent effect on mobility due to roll direction. Two unimpaired subjects showed no differences between level and slope conditions.

TABLE 6. Effect of Floor Slope on Movement in the Cabin

		Average Rate of Movement (ft/s)	
Subject	Handicap	Flat and Level	5^o Nose Down 5^o Right Roll
1	Amputee	2.29	2.48
2	Mental Deficiency	1.29	1.16
3	Obesity	2.45	2.32
4	Mental Deficiency	3.93	2.28
5	Obesity	4.09	2.90
6	Blind	3.17	2.75
7	Multiple Sclerosis	1.86	1.82
8	Mental Deficiency	5.00	3.79
9	Cerebral Palsy	4.93	4.27
10	Blind	4.35	3.53
11	Birth Defect	4.65	3.13
12	Mental Deficiency	3.15	2.77
13	Mental Deficiency	3.94	2.63
14	Mental Deficiency	3.30	2.85
15	Mental Deficiency	3.36	1.84
16	Mental Deficiency	2.94	2.46
17	Paraplegia	1.47	1.67
18	Paraplegia	1.54	1.85
19	Paraplegia	2.18	2.77
20	Paraplegia	2.01	2.12
21	Paraplegia	0.84	0.61

The Seat 2 exit route was also used in tests to evaluate the effect of vision impairment on movement in the cabin. Each participant in these tests was led to the exit before being seated for the test. The results of these tests are shown in Table 7. Blind subjects moved faster than blindfolded sighted individuals in these tests. A 71-yr-old subject included in the blind group could not remember instructions and required 47 s to accomplish the task. Individuals with vision of less than 20/200 who could distinguish forms and objects in a well-lighted cabin moved approximately 33 percent faster than their totally blind colleagues. However, these subjects stated that their movement would be further impaired under dim lighting conditions.

TABLE 7. Effect of Vision Impairment on Movement Within the Cabin

Subject	Number of Subjects	Mean Times (s)	Rates of Movement (ft/s)
Vision less than 20/200	7	9.73	4.26
Totally blind	14	14.24	2.82
Sighted persons with blindfolds	22	16.17	2.26
Sighted persons without blindfolds	22	6.00	7.87

Subjective Comments. A survey was made of the 126 handicapped subjects in this study to obtain information on each subject's disability, flight experience, preferred method of assistance, aids normally used, and suggestions for improvement of air travel for handicapped passengers. The results of this survey are shown in Appendix D.

Assistance to Handicapped Passengers. Assisting handicapped passengers in an aircraft cabin is difficult because of space limitations generated by the seat configurations. Fixed armrests, restrictive seat pitch (distance between similar points on seats), and restrictive aisle widths made assistance difficult and interfered with movement. Passenger congestion also interfered with those assisting handicapped subjects. Assistance in operating the seat-belt was necessary for most handicapped subjects, especially those who lacked strength or muscular coordination.

Deaf subjects required visual demonstration or written notes describing what they were expected to do. These subjects followed the directions of test personnel and the actions of fellow subjects in responding to test requirements. It should be noted that although some deaf passengers could read lips, they missed oral announcements unless they knew to expect them.

Some elderly subjects, particularly those easily confused and those lacking mental retention ability, required additional instruction. During some tests, these subjects required continual direction; otherwise, they walked past exits or did not complete the task. They were easily distracted, and their short attention span caused them to forget the assigned task.

Assisting passengers with partial or total paralysis in one side of the body presented a special problem. The aisle did not provide enough space for an assistant to help directly from the side, and leading these subjects from the front only slightly improved movement rates. Assistance from the subject's good side was more effective because the subject could use a functional arm for support, but sideways movement down the aisle was slower than forward movement. Carrying would have been necessary to move severely afflicted subjects at an

acceptable rate in a survival situation. When a handicapped subject had some function in his afflicted side, assistance did not improve his rate of movement.

Assistance to paraplegic subjects depended primarily on their weight and size and on the physical ability of the assistant. Paraplegic subjects were concerned about receiving injury to the lower half of their bodies because of complications of healing. Therefore, plans to handle, carry, or move paraplegics included an awareness not to drop, bump, drag, or otherwise cause exposure to bruising. Female paraplegics generally exhibited less arm strength than males in moving themselves in the cabin. Lifting subjects directly by the arms may dislocate the upper arms of medium to heavy individuals. Thus, when the assistant was physically able, a "child carry" (cradled in outstretched arms) proved effective and caused less discomfort. An assistant to a 150-lb female paraplegic readily carried her in two trials by using this method over the Seat 2 exit route. A 124-lb male paraplegic subject was carried by five different male passengers in five group evacuation tests, all by the piggyback method--their own choice--with no instructions on type of carry to use. Once on the back of an assistant, the subject placed his arms around the assistant's neck or shoulders. All assistants were able to move down the aisle to the exit at an acceptable rate. Another male paraplegic subject, weighing 175 lb, was pulled along the floor on a blanket by an assistant with the subject leaning on his side to clear the narrow aisle (Figure 7). The assistant wore shoes with leather soles and rubber heels and slipped occasionally but moved steadily and at an acceptable rate over the distance of four seat rows.

Figure 7. A paraplegic test subject being assisted down the aisle with the aid of a blanket.

Dummies simulating nonambulatory passengers were carried by two methods. The first required two assistants, one holding the upper torso with his hands under the arms and locked over the chest, positioning the back of the dummy's shoulders on the assistant's chest, with the other assistant carrying the legs. If only one assistant was available, he could carry the upper torso in the same manner and walk backward. Use of this method could result in a delay at the exit while the subject is turned around for a feetfirst entry onto an evacuation slide. This problem was avoided when the subject was carried with his feet toward the exit direction. Time was saved in a headfirst carry when the lead assistant continued past the exit accessway until the assistant carrying the legs could enter the accessway. This was practical only when other passengers had already evacuated, so that congestion did not interfere with the process. During the tests, three dummies were placed on the slide headfirst since their assistants had not been instructed to do otherwise. In an actual emergency, such action would likely prove hazardous.

The second method required three assistants to hold the dummy in their arms above the seat backs while they moved sideways down the aisle. In this manner, the assistants were able to move a 200-lb dummy down the aisle at an acceptable rate.

Cerebral palsy victims vary in degree of mobility limitations. Total or partial inability to coordinate muscular movements limits many of them to a slow, unsteady walk. Chronic muscular contractions were present in the test subjects of this category, and their limbs resisted bending during assistance. Walking was difficult because their balance was easily upset and the stress of the test environment tended to reduce their ability to concentrate on muscular coordination. Leading these subjects with a gentle pull in the upward direction improved rates of movement up to 30 percent. Five of the eight cerebral palsy subjects, who normally used wheelchairs, moved less than 1 ft/s, a rate inadequate for emergency aircraft evacuations.

Table 8 lists times and rates for the handicapped subjects who were assisted over the Seat 2 exit route. The subjects were led either by the arm from the front or with the assistant's arms around the subject's waist, moving sideways. In one trial, the assistant placed the good right arm of the subject over his right shoulder and moved a severely afflicted hemiplegic along the aisle in a modified piggyback carry. This method was not successful because the assistant's legs interfered with the subject's movement. Two subjects, a hemiplegic and an amputee with a leg prosthesis, moved slower with assistance than without assistance. These subjects stated that they took shorter steps while being assisted for fear of losing their balance. They attained their best rates moving unassisted and using seat back support.

Group Evacuations. Seating of handicapped passengers in a normal passenger population will result in, at most, an occasional minor inconvenience to other passengers during ordinary flights. If, however, circumstances deem that the passenger cabin must be speedily evacuated, placement of the handicapped passengers becomes important. Information for the study of seat location was drawn from three test series: using an actual handicapped passenger in a passenger population of 24, using simulated handicapped

TABLE 8. Effect of Assistance in Moving to the Exit From the Seat 2 Location

Subject Handicap	Age	Sex	Fuselage Attitude	Subject Unassisted Time (s)	Subject Unassisted Rate (ft/s)	Subject Assisted Time (s)	Subject Assisted Rate (ft/s)
Amputee	66	M	5^{o} Nose Down 5^{o} Right Roll	15.17	2.48	17.16	2.01
Mental Deficiency	67	M	5^{o} Nose Down 5^{o} Right Roll	24.99	1.65	21.55	2.00
Mental Deficiency	61	F	5^{o} Nose Down 5^{o} Right Roll	19.71	1.84	13.01	3.02
Mental Deficiency	25	F	Flat & Level	16.46	3.05	11.67	4.14
Mental Deficiency	67	M	Flat & Level	31.00	1.29	22.28	2.32
Mental Deficiency	33	F	Flat & Level	18.73	2.88	13.40	3.00
Mental Deficiency	60	F	Flat & Level	13.51	3.30	13.49	3.71
Mental Deficiency	60	F	Flat & Level	16.86	2.94	17.82	3.35
Cerebral Palsy	55	F	Flat & Level	63.20	.62	44.16	.95
Multiple Sclerosis	64	F	Flat & Level	53.00	.78	49.21	.80
Hemiplegia	60	M	Flat & Level	Incomplete		59.92	.59
Hemiplegia	64	F	Flat & Level	274.12	.33	143.18	.55
Hemiplegia	60	F	Flat & Level	21.77	2.16	24.79	2.46
Hemiplegia	68	F	Flat & Level	21.92	2.61	16.63	1.98
Hemiplegia	69	M	Flat & Level	41.33	1.14	41.76	1.15
Paraplegia	28	F	Flat & Level	Incomplete		10.91	4.81*
Hip Injury	80	F	Flat & Level	18.24	2.28	19.15	2.51
Deaf	32	F	Flat & Level	15.12	1.49	15.18	3.38
Paraplegia	15	M	Flat & Level	13.50	2.05	15.75	2.39*

*The subject was carried by the child-carry method to the exit. All other subjects were led by the hand or arm.

passengers (two or three dummies) in a passenger population of 23, and using simulated handicapped passengers (eight dummies) in a passenger population of 50.

Tests With a Paraplegic Subject. The test subject for this series was a 124-lb, 19-yr-old male paraplegic who, though dependent on a wheelchair for general mobility, could move without it and, in fact, seldom used his chair at home. Six tests were conducted. The seating location for the handicapped subject in each of the six tests is shown in Figure 8. For these tests, an assistant was seated to the right or left of the handicapped passenger. The following times are the total evacuation times for all 24 passengers on each of the six test runs:

Test No.	Total Evacuation Time (s)
1	24.92
2	26.84
3	21.32
4	22.14
5	22.20
6	25.05

In the first test the assistant was able to position the paraplegic subject on his back before the rest of the passengers could begin to move through the exit and was, therefore, able to stay with the flow. In the second test the back-carry position was difficult to assume; this resulted in a temporary obstruction of the exit and a 6-s delay in evacuation. The 10-s door-opening delay on the third test allowed ample time for the assistant to lift and position the paraplegic before passenger flow began and thus avoid delay. On the fourth test, the assistant never comfortably positioned the paraplegic subject on his back. This caused him (and also those behind him) to lag behind the main passenger flow enough to delay both his own evacuation and that of several other passengers. The fifth test duplicated the first except that learning improved the total test time. No difficulty occurred in lifting or moving the paraplegic passenger.

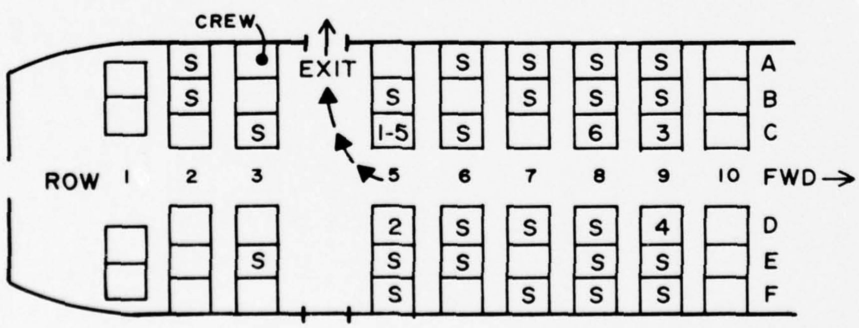

Figure 8. Handicapped seat positions and use by test number for evacuation tests involving a paraplegic male. S in seat indicates normal subject. Arabic numeral in seat indicates paraplegic location and test sequence.

The final test was unique among the six tests because the paraplegic passenger was allowed to evacuate the cabin without assistance. He positioned himself in the aisle so that a feetfirst scoot was possible. Although his movements were quick, he fell behind when traffic really began to move and delayed those behind him about 4 s. The obvious effort to avoid overrunning the paraplegic undoubtedly was a major reason that the total delay was more than 2 s.

One observation from the first five tests is that better evacuation times generally resulted when the handicapped passenger and his assistant were seated far from the exit.

Tests With Totally Incapacitated Subjects. These tests were designed to study the effects on passenger flow time that would be imposed by totally incapacitated passengers. In Test 1, two dummies, simulating handicapped passengers, were placed in opposing aisle seats (5C and 5D) near the exit (Figure 9). In Test 2, two dummies were placed in the seats most distant from the exit (10A and 10F) (Figure 10). In Test 3, three dummies were used; two were placed as in Test 2 and one was located in a midcabin aisle seat (7D) (Figure 11). A passenger mix of 16 males and 7 females (15 to 54 yr of age) made up the unimpaired subjects.

The sequence of events for each test was:

a. The cabin attendant gave a preflight briefing and checked seatbelts.

b. A delay was scheduled before each emergency evacuation to discourage anticipated moves by subjects.

c. During the "preemergency delay" the cabin attendant instructed the subjects who were to serve as assistants.

d. An alarm bell and a flash bulb were used to initiate the evacuation and the cabin attendant announced the evacuation.

e. A 10-s delay at the doorway was imposed to simulate door opening and slide inflation times (these were ground-level tests and the exit had no door closure).

In the first test, dummy seating positions were in the exit area. The man assisting the 105-lb dummy from Seat 5D skillfully worked into the flow of passengers without delay (Figure 12). Evacuation of the 200-lb dummy from Seat 5C was more difficult and a delay of about 3 s resulted. Passengers who evacuated just before the dummy pairs took an average of 1.4 s per passenger and, if this same tempo had prevailed, the total passenger complement would have taken about 32.3 s to leave the cabin. A rate of 1.61 passengers per second established by the remaining passengers, however, greatly improved the total time (30.23 s). The increased passenger flow was attributable to the flight attendant, who issued more vigorous and excited commands during the last portion of the evacuation.

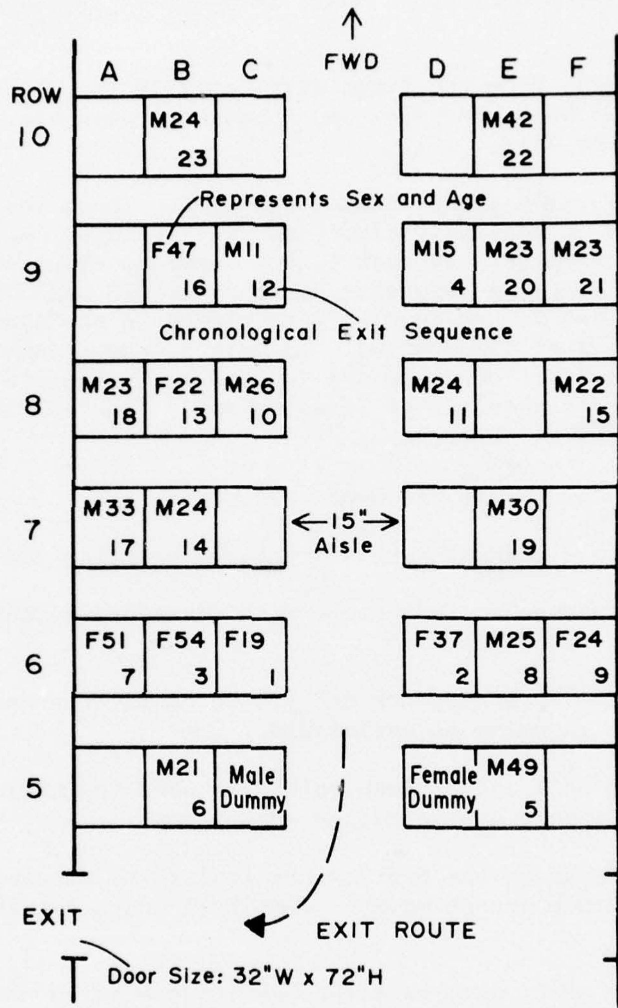

Figure 9. Seat locations near the exit indicate the 200-lb male dummy and a 105-lb female dummy in the passenger load.

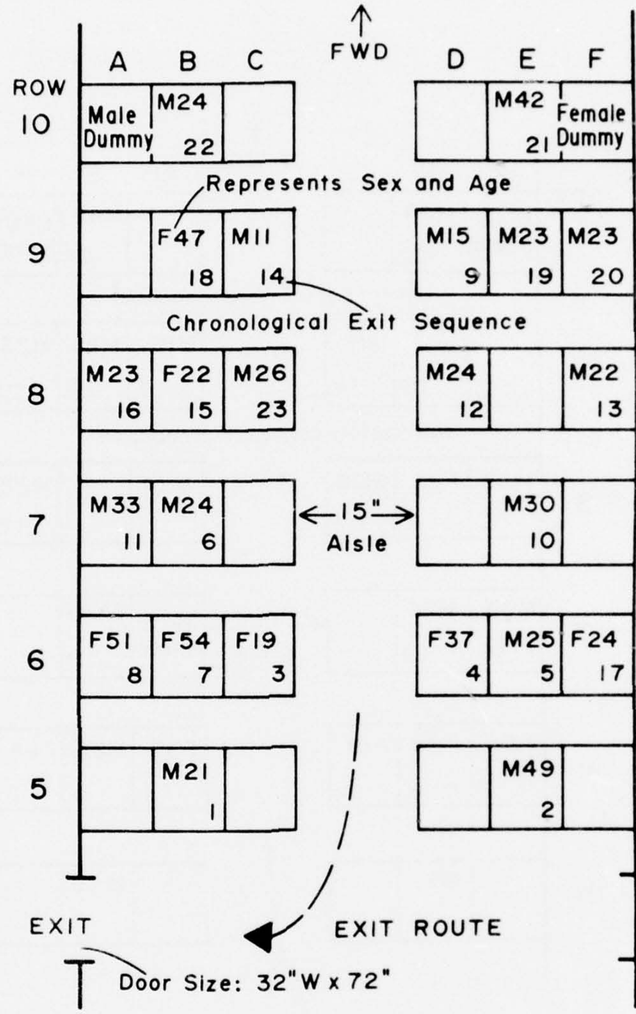

Figure 10. The 200-lb male dummy and 105-lb female dummy are located away from the exit in the passenger group.

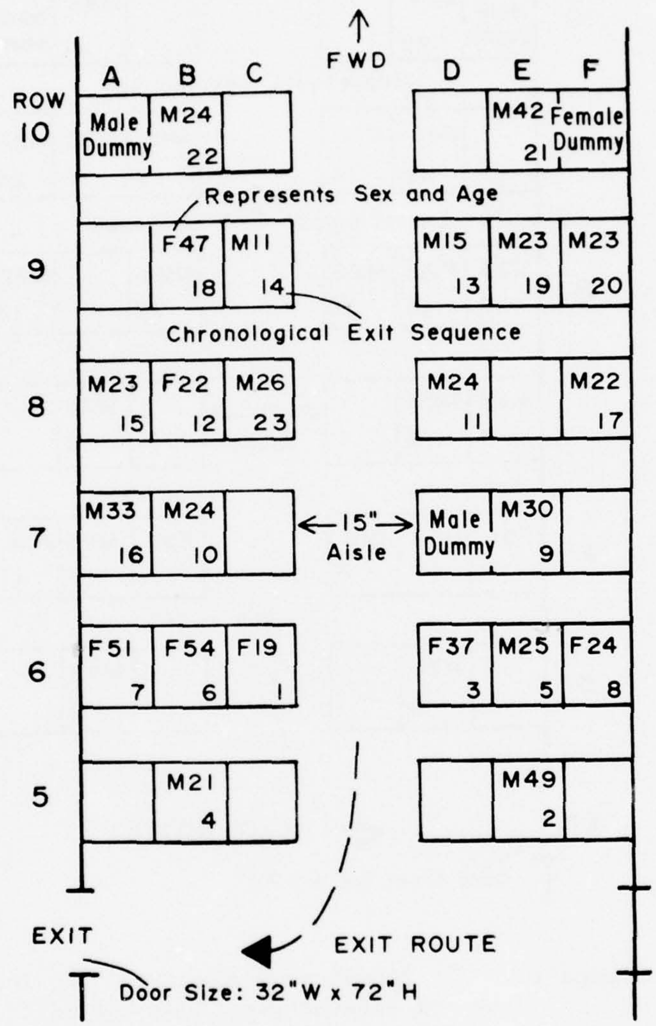

Figure 11. Seat locations for a female and two male dummies are shown for the third test of the series evaluating the effects of seat location on total evacuation time.

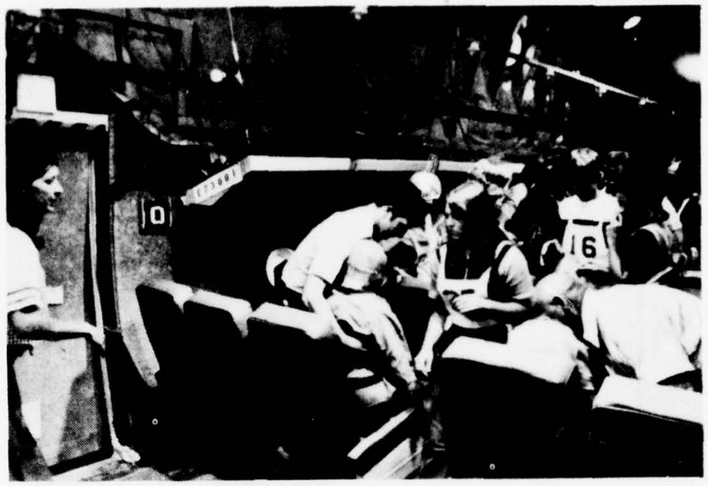

Figure 12. Male passengers assisting the male and female "incapacitated passengers" from their seats located near the exit to evaluate effects on total evacuation time.

Placing the dummies at the farthest point from the exit, the extreme end of the passenger population, as in Test 2, allowed the cabin attendant to establish a good evacuation flow immediately. The total evacuation took only 25.04 s. The flow rate dropped from 1.82 passengers per second to 0.76 passenger per second during the evacuation of the dummies. There was little delay in this test because most passengers were not detained by the action required to move the dummies and because those passengers moving the dummies had ample time to position them for transport while the forward line of passengers was leaving the aircraft.

The effect of seat location for handicapped passengers on evacuation time is shown in Figure 13. Seventeen passengers were clear of the exit in the first 20 s of Test 2, but only six passengers (including two dummies) exited in the same time of Test 1. This delay, in the early phase of an evacuation, would be critical if the total time available for an evacuation were limited because of fire, toxic smoke, etc.

The third test placed an additional dummy midway in the cabin (Figure 14) to demonstrate the delay, if any, imposed on those passengers forward of that point. The first passengers were delayed at the exit for 5.8 s (compared to 10 s for the other two tests). A comparison of Test 3 with Test 2 (Figure 15) shows similarity after the evacuation of the first male dummy.

<u>Tests to Evaluate the Effect of Grouped Handicapped Passengers</u>. Two tests were conducted to evaluate the effects of grouped handicapped passenger seating on evacuation. Eight anthropomorphic dummies were placed among 42 able-bodied test subjects in a manner so as to simulate a group of nonambulatory passengers. These subjects were previously experienced in

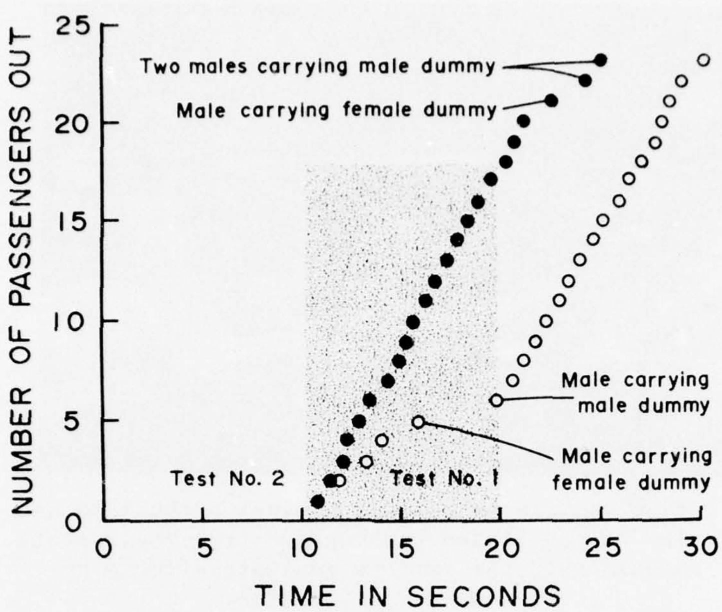

Figure 13. Comparative evacuation tests with two incapacitated passengers seated near the exit (Test 1) and two seated away from the exit (Test 2). Note the difference in numbers evacuated at the end of 20 s.

Figure 14. Passengers seated for the third test. A 200-lb male dummy was placed midway in the passenger group in addition to the male and female dummies located forward.

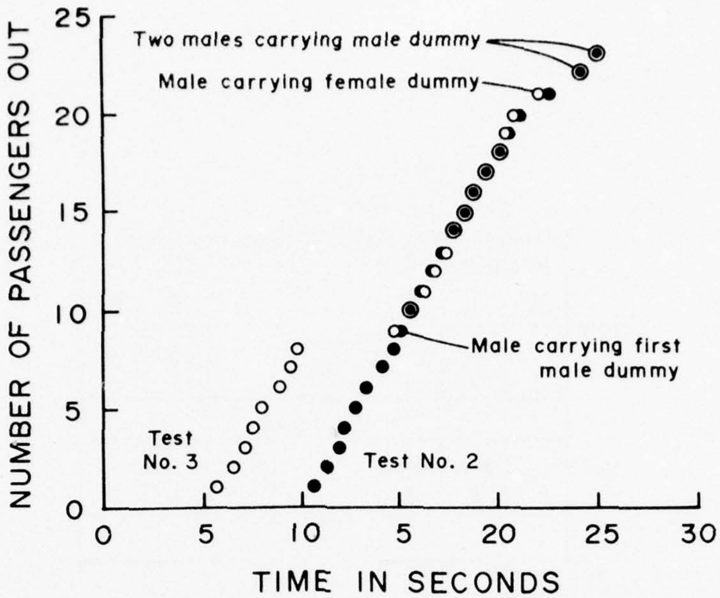

Figure 15. Comparative evacuation tests with two incapacitated passengers seated away from the exit (Tests 2 and 3) but with an additional incapacitated passenger seated in a center aisle seat (Test 3).

evacuation tests. In the first test, the group of dummies was seated away from the exit (Figure 16). In the second test the group was seated near the exit (Figure 17). A 32-in-wide by 72-in-high exit with a pre-positioned two-lane inflatable slide was used for these tests. A 10-s test delay at the exit was imposed at the beginning of the test to simulate the activation time of the exit door and slide. A cabin attendant stationed at the exit maintained control of passenger flow and instructed male subjects to assist in moving the dummies.

The total evacuation time for the first test was 77 s, equivalent to an average rate of 0.62 passenger per second for 48 passengers; two dummies were left aboard. One of the dummies left aboard (10E) was abandoned by the subject on its right (10F), who then helped to evacuate the dummy in the aisle seat (10D) of that row. A male subject seated behind the exit, in Seat 3E, moved all the way forward to help with the dummy in Seat 10D. Two male subjects in Seats 5A and 5C climbed forward over the seat backs on the left side of the cabin to assist a dummy in Seat 9B.

The total evacuation time for the second test was 86 s for 50 passengers, equivalent to an average rate of 0.58 passenger per second. All dummies were removed on this test.

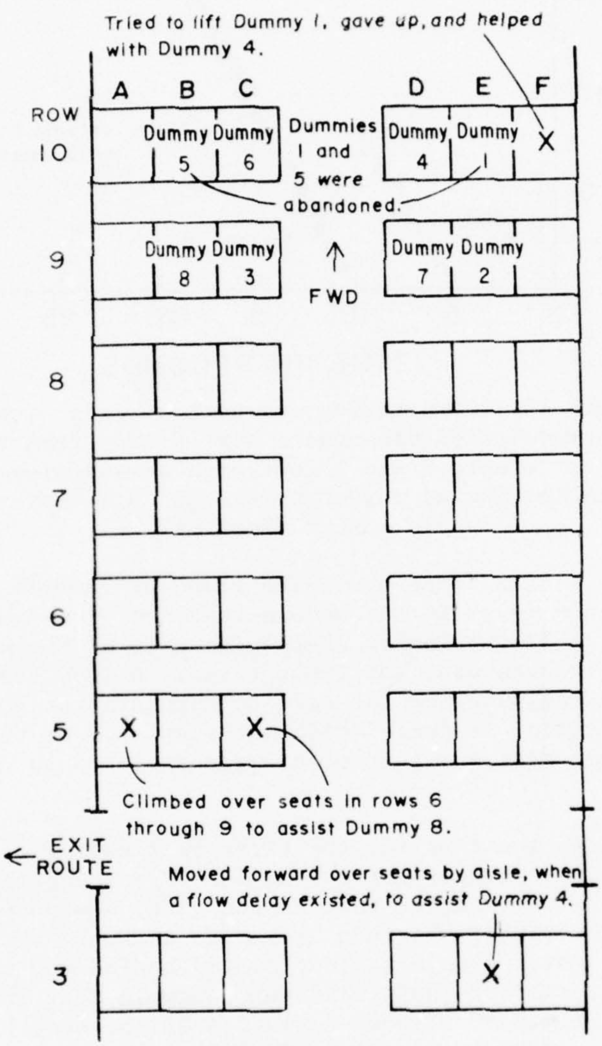

Figure 16. Eight dummies seated at the extreme end of the evacuation line to demonstrate the effects of grouped seating of handicapped passengers on the evacuation flow.

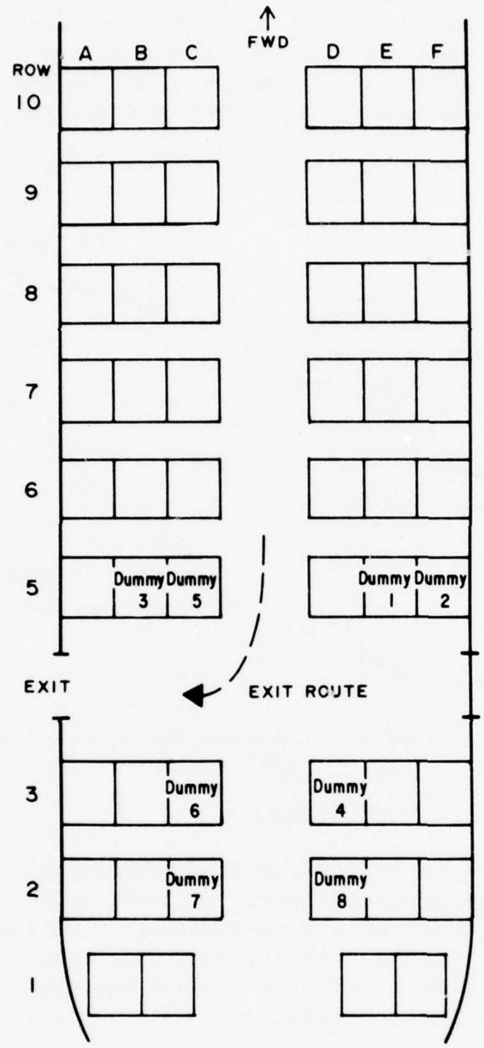

Figure 17. Location of dummies in tests to evaluate the effects of totally handicapped passengers on evacuation flow rates.

It is expected that total flow times for both tests would have been similar if all dummies had been removed in the first test; however, the evacuation patterns during the tests were significantly different (Figure 18). In the first test, in which dummies were located far from the exit, 33 passengers evacuated in the first 45 s. However, in the second test, in which dummies were located near the exit, only nine passengers had evacuated the cabin at that time.

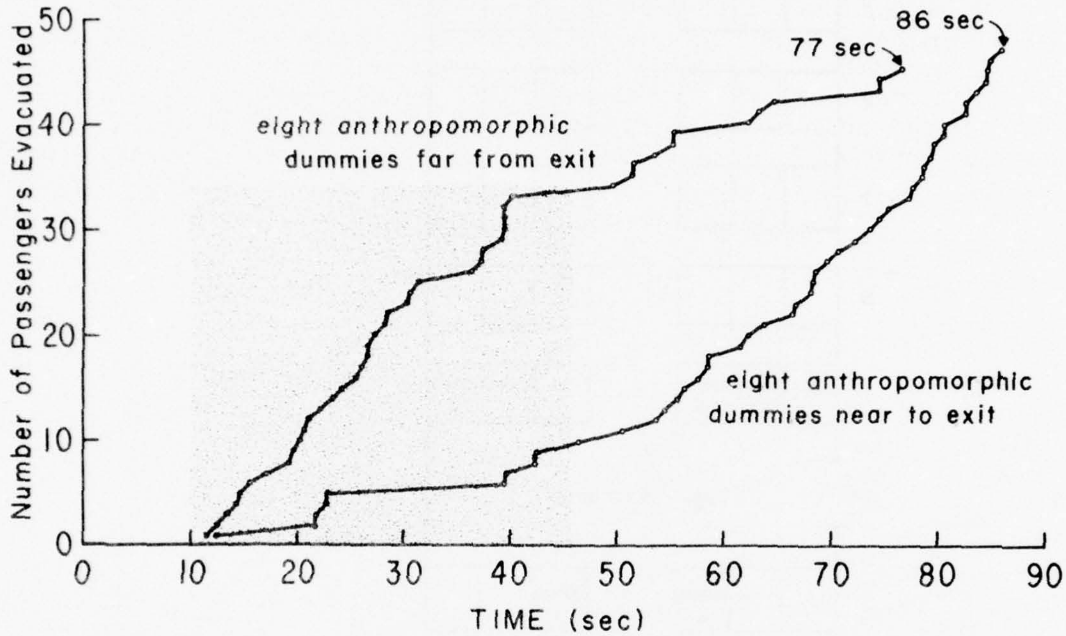

Figure 18. Comparison of two evacuations including eight incapacitated passengers (dummies) in each test. In Test 4 the incapacitated are seated away from the exit and in Test 5 they are seated near the exit to demonstrate the effects of handicapped seating on the evacuation flow.

Effect of Exit Configuration on Evacuation. Thirty-four tests were conducted in this series. Seventeen tests utilized a 32-in-wide, 72-in-high floor-level exit with a preinflated slide oriented 39° down from the horizontal. The remaining 17 tests used a 20-in-wide, 36-in-high "overwing" exit with an inside step-up of 20 in and an outside stepdown of 27 in. Approximately 50 subjects were used on each test. Since this test phase required almost 1,700 subject exposures, it was impractical to obtain naive subjects for each test. Two sets of 50 subjects were used, one for the floor-level exit tests and one for the overwing exit tests. To reduce the effect of subject learning by experience, two tests were conducted with each exit configuration prior to the actual data tests. The remaining 15 tests in each exit configuration were divided into three handicap categories, each

containing five tests. The first test in each category was a control test, conducted without handicapped subjects to provide an indication of the relative importance of the learning experience.

Each series of tests involving handicapped subjects began with two simulated handicapped subjects among the test population of 50 subjects. This number (two) was increased by two for each succeeding test, so that each handicap category contained data on evacuations with two, four, six, and eight handicapped subjects. When a handicapped subject replaced an unimpaired subject, the unimpaired subject withdrew from the test so that the test population remained constant. A designated seating pattern (Figure 19) was established for the handicapped subjects and remained consistent in all tests. Totally handicapped subjects were represented by anthropomorphic dummies. Other handicapped subjects were simulated by experienced research personnel. The handicaps represented in each category and their seat positions are listed in Table 9.

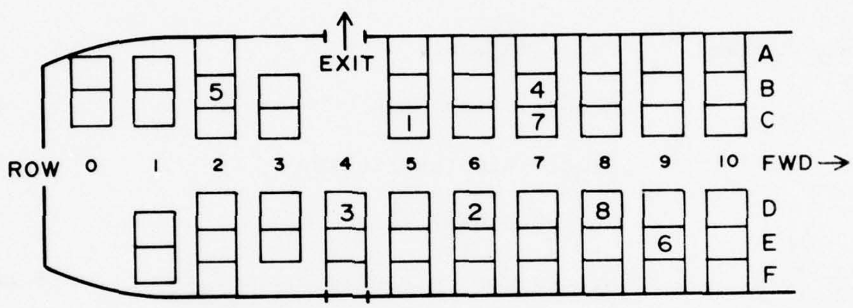

Figure 19. *Simulated handicapped seat positions and sequence of use.*

Data from these tests are shown in Tables 10 and 11. The times shown on these tables include a delay of 10 s imposed after test initiation to simulate opening the exit. In general, evacuation times increased as the number of handicapped subjects was increased. This increase is most significant in the totally handicapped category, is less significant in the lower limb and partial immobility category, and is least significant in the upper limb and sensory handicap category.

DISCUSSION

These experiments, while lacking some of the effects of genuine emergencies, represent the optimal performance to be expected of handicapped passengers. In these tests most of the severely handicapped subjects--those having little or no use of their lower limbs and those requiring absolute concentration for movement--gave efforts that appeared to represent their maximum potential. Unfortunately, many of the nonhandicapped subjects did not provide such absolute commitment.

Anthropomorphic dummies resemble the totally incapacitated subjects in their inability to look after themselves or aid in any assistance rendered them, but they were more difficult to handle than living subjects. Assistants

TABLE 9. Handicaps, by Category, and Their Seat Positions

Handicap Category	Subject Characteristics	Seat Location(s)
Total Incapacitation	110-lb dummy	1
	170-lb dummy	5
	200-lb dummies (6)	2,3,4, 6,7, and 8
Lower Limb and Partial Immobility	Full-leg cast	1
	General arthritis	2
	Single hip restriction	3
	Full-leg cast (both legs)	5
	Single foot or ankle casts	6 and 8
	Muscle atrophy	7
Upper Limb or Visual	Blind	1 and 8
	Single arm cast/sling	2 and 3
	Shoulder brace/sling	4
	Back brace	5
	Shoulder brace (single)	6
	Neck brace	7

TABLE 10. Evacuation Time When Using a Floor-Level Exit

Handicap Category	Test Number	Number of Simulated Handicapped Passengers	Total Evacuation Time (s)	Increase In Total Evacuation Time* (s)
Totally Incapacitated Passengers (dummies)	1	Control (no handicap)	62.7	
	2	2	80.1	17.4
	3	4	98.8	36.1
	4	6	108.2	45.5
	5	8	112.5	49.8
Lower Limb and Partial Immobility	6	Control (no handicap)	65.5	
	7	2	68.0	2.5
	8	4	74.4	8.9
	9	6	77.1	11.6
	10	8	74.0	8.5
Upper Limb and Sensory Handicaps	11	Control (no handicap)	57.0	
	12	2	61.3	4.3
	13	4	61.9	4.9
	14	6	60.9	3.9
	15	8	66.0	9.0

*Relative to control test

TABLE 11. Evacuation Time When Using an Overwing Exit

Handicap Category	Test Number	Number of Simulated Handicapped Passengers	Total Evacuation Time (s)	Increase In Total Evacuation Time* (s)
Upper Limb and Sensory Handicaps	16	Control (no handicap)	60.7	
	17	2	64.1	3.4
	18	4	66.4	5.7
	19	6	66.2	5.5
	20	8	69.7	9.0
Lower Limb and Partial Immobility	21	Control (no handicap)	61.9	
	22	2	70.7	8.8
	23	4	79.6	17.7
	24	6	75.5	13.6
	25	8	79.2	17.3
Totally Incapacitated Passengers (dummies)	26	Control (no handicap)	59.6	
	27	2	73.9	14.3
	28	4	72.8	13.2
	29	6	96.3	36.7
	30	8	102.1	42.5

*Relative to control test

handling the dummies were concerned about their own efforts and possible injury rather than gentle treatment of the dummies. As a consequence, although the evacuation times are representative, handling techniques would have been different in many cases.

The case in which two dummies were not evacuated could be attributed to the following factors:

a. The size, age, and general health of the would-be assistants were not conducive to the task.

b. The would-be assistants were unable to reach the dummies.

c. The area was cleared of unimpaired passengers before all dummies were accounted for.

d. Most passengers in the rear of the cabin were unaware of the situation in the forward part of the cabin.

e. The narrowness of the seat aisles and main aisle restricted assistance.

With regard to the subsequent test in which all dummies were evacuated:

a. Subjects were concerned about leaving the dummies in the previous test.

b. Efforts by the assistants were observed by other subjects who were prompted to help where needed.

c. The cabin attendant was in the immediate area of the dummies and asked the assistants to help.

d. The distance to the exit was much shorter; thus, less effort was required of the assistants.

The test results indicate that the time delays in evacuations did not always increase in proportion to the difficulties encountered in a specific test. This data scatter is commonly observed in aircraft evacuation tests and can be attributed to the following factors:

a. Each subject or group of subjects differs in degree of aggressiveness and commitment to test requirements both in initial attitudes and with the boredom of repetition.

b. Small groups behave differently in unusual, stressful situations.

c. Each disabled person deals with his disability in his own way.

d. The restriction presented by simulated casts and braces, as used in these tests, could often be neutralized by efforts of the subject, since in the interest of safety these devices were made weaker than the human body.

e. Assistance techniques improved with practice.

f. Assistants became tired or bored as the tests continued.

g. Subjects simulating handicapped passengers adapted to the simulation.

Effects of exit types on the movement of handicapped passengers are quite evident, particularly for nonambulatory passengers.

Although the test data indicate that the Type III exit is better for evacuating nonambulatory passengers from the cabin, the tests did not include the problems of moving from the wing to the ground, an action that could further injure a nonambulatory passenger. More time was consumed in properly orienting the totally incapacitated passengers for movement on the slide than in simply depositing these passengers through the smaller exit and onto the wing. In some tests, handicapped passengers stayed in the seat row until passengers in the main aisle encouraged them to move. Assistance for these handicapped passengers was not mandatory but was most effective in making minimum support available and in discouraging the shoving tendencies of other passengers. Exit type had no appreciable difference in total group evacuation times when simulated upper limb and sensory handicapped subjects were tested. However, an increase in evacuation time ranging from 0.6 to 2.1 s per additional handicapped person was noted. Individuals with simulated lower limb handicaps increased total evacuation times by a range of 2.2 to 4.4 s per person through the floor-level exit. The step-up and stepdown feature of the overwing exit, and the restrictive seat aisleway leading to the exit, made use of this exit more difficult for those with lower limb disabilities. Assistance on the wing outside the overwing exit was shown to be important but varied widely because of lack of response to the flight attendant's commands to stop and help. The presence of totally incapacitated passengers (dummies) increased evacuation times through the floor-level exit from 6.2 to 9.0 s per handicapped person and through the overwing exit from 3.3 to 7.1 s per handicapped person. Positioning incapacitated subjects for slide entry consumed the extra time at the floor-level exit.

Problems exist for the paralytic passenger regardless of which type of exit he attempts to use. The floor-level exit with an inflated slide demands care in body orientation so that the sides of the exit can be cleared and still afford a clean entrance onto the slide. When a prosthesis or cast is involved, the passenger must take care to avoid puncturing the slide. The overwing exit demands that handicapped passengers be able to maneuver stiff or restricted lower limbs through the narrow opening while negotiating a step up and then down. These passengers are then faced with the more difficult problem of moving from the wing to the ground.

Passengers with upper limb and sensory handicaps have the least delaying effect on passenger flow times once their seatbelts are released. Assistance

is particularly effective for passengers who cannot remember instructions, regardless of the reason.

SUMMARY AND CONCLUSIONS

Mobility Patterns. Handicapped subjects were interviewed and then timed as they moved, unassisted, to an exit located 29 ft from a midcabin window seat. This measurement approximates the longest distance from a seat to an exit in modern transports. Ninety-six percent of the ambulatory handicapped subjects reached the exit in 30 s or less, but only 37 percent of the nonambulatory handicapped reached the exit in that time. These latter subjects would probably require assistance from other passengers or the crew during a critical evacuation. This conclusion is in agreement with the results of previous testing of nonhandicapped individuals, evacuation demonstrations, and analyses of crash data, which indicate that passenger movement at a rate of at least 1 ft/s is minimal for a successful evacuation.

Analysis of movement from the window seat to the exit indicated that subjects expended up to 50 percent of the total time in moving from the window seat to the aisle. Thus, it appears that an advantage would exist for the handicapped passenger seated in an aisle seat rather than in a window seat.

Assistance for Handicapped Passengers. The average passenger cannot be expected to know the best methods for aiding a nonambulatory passenger in his movement to the exit, but the handicapped passenger can usually provide instruction. Lifting under the arms is often painful, particularly for the heavy passenger. Belts can sometimes be used to lift the disabled passenger as he places his arms over the carrier's shoulders. The conventional fireman's carry, child carry, and two-man carry can be used to advantage. Carrying "feetfirst" can save a turn at the exit. Prior experience and instruction for crewmembers would be valuable so that they could provide guidance in emergencies. Canes, crutches, and similar aids did not improve escape times in the tests and could present a hazard during movement in the cabin and down the escape slide. Seat backs and armrests provided valuable support for individuals moving down the aisle.

Suggestions by the Handicapped Subjects. Aircraft cabins are not equipped or arranged to effectively accommodate seriously handicapped passengers. Handicapped subjects who have flown are aware of this and offered the following suggestions:

a. Increase main aisle widths to accommodate wheelchairs.

b. Provide removable armrests on the center aisle portion of the seat unit to facilitate seat-to-wheelchair transfer and vice versa.

c. Provide passenger information cards printed in Braille.

d. Provide audible voice or tone markers at exits and lavatories.

e. Provide audible indication when "Fasten Seat Belts" and "No Smoking" signs are lit.

f. Provide support handles where needed.

g. Provide stabilizing ropes on inflated slides to insure proper body orientation and speed control.

h. Provide mockup emergency equipment to allow blind passengers to become acquainted with equipment items by touch.

i. Provide some minimum instructions such as a sound movie to be presented where groups of handicapped individuals meet to inform handicapped travelers of the emergency provisions of aircraft.

j. Include knowledgeable handicapped persons in portions of training of airline personnel dealing with the problems of handling handicapped passengers.

Effect of Seat Locations. The average ambulatory handicapped passenger appears to possess adequate mobility for escape. He could be seated anywhere in the cabin except in an exit row or a primary overwing exit route, where he might impede the early stages of an evacuation or be injured by the rush of other passengers. Egress by way of overwing exits on aircraft without wing-to-ground descent devices would expose handicapped passengers to injury.

Nonambulatory passengers requiring assistance were more efficiently aided when seated away from the congested exit areas. Seating of two nonambulatory passengers, both of whom may require assistance during an emergency evacuation, across the aisle from each other could result in interference as assistants attempt to move the handicapped individuals into the aisle.

A passenger paralyzed on one side can move on his own or be assisted by others if he is seated with his functional side toward the aisle.

If nonambulatory passengers are seated in a group, the group should be seated in the cabin so that they, and their assistants, would be at the end of a line of evacuees so as to not interfere with the evacuation of other passengers and to avoid crowding by other passengers during their preparation for evacuation.

REFERENCES

1. Federal Aviation Act of 1958, Sec. 404. (72 Stat. 760, 49 U.S.C. 1374), Carrier's Duty to Provide Service, Rates, and Divisions (b) Discrimination, and Sec. 1111. Authority to Refuse Transportation.

2. Lay Acceptance Criteria, Air Traffic Conference, Trade Practice Manual, Resolution 10.6, page 1, effective December 19, 1962.

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APPENDIX A

CASE HISTORIES OF HANDICAPPED INVOLVED IN INCIDENTS/ACCIDENTS

Case histories of aircraft accidents/incidents involving the evacuation of handicapped passengers are presented. Some incidents are not documented in final reports but were noted in crew or passenger statements or through interviews.

1. A jet crashed on takeoff at London, England. One of the flight attendants, after assisting in the safe evacuation of many passengers, died while attempting to aid an elderly, crippled woman.

2. NTSB-1-0058, Stockton, California, October 16, 1964. An elderly couple had difficulty getting to an exit and had to be assisted by a flight attendant. This action caused a temporary delay in the attempt of the first officer to evacuate a crippled passenger.

3. NTSB-1-0072, Saugus, California, December 30, 1964. Several passengers and a flight crewmember assisted in the emergency deplaning of two infirm, elderly men (boarded in wheelchairs) through the rear exit.

4. NTSB-1-0049, Orlando, Florida, August 21, 1963. The captain and a flight attendant helped a crippled woman deplane during an emergency by lifting and placing her on the escape slide.

5. NTSB-1-0016, Boston, Massachusetts, September 24, 1961. The flight crew experienced difficulty with an elderly woman who, even though aware of the emergency, stayed in her seat and demanded a wheelchair. The passenger's ability to walk was confirmed by her husband, so she was ordered to move to the exit. She was then assisted through an overwing exit by two passengers and a flight attendant (not documented).

6. NTSB-SA401, Knoxville, Tennessee, August 2, 1962. An elderly crippled female passenger was carried to an alternate exit by the first officer when the main cabin door was found to be inoperable. The captain also assisted an elderly male passenger.

7. NTSB-1-0037, Miami, Florida, December 15, 1972. A young male passenger with a cast on his leg was assisted from the plane and down the slide by the copilot and a fireman after the main emergency evacuation had taken place (FAA report) (not documented).

8. NTSB-1-0014, Pittsburgh, Pennsylvania, June 12, 1973. A flight attendant and another woman had to assist an obese elderly female passenger in deplaning (FAA report).

9. NTSB-1-0015, Denver, Colorado, July 19, 1971. A flight attendant had to help an obese female passenger through an overwing exit onto the wing (FAA report).

10. NTSB-1-0047, Burbank, California, December 16, 1970. An 82-yr-old female passenger and a male passenger on crutches had to be assisted to the exit and helped onto the slide after the main emergency evacuation had taken place (FAA report).

11. FAA 7-0019, Columbus, Ohio, April 28, 1973. A female passenger with a leg brace and cane, accompanied by her husband, who had a heart problem, had to be assisted down the slide.

12. NTSB-1-0038, St. Louis, Missouri, November 1, 1972. Three elderly passengers (70 yr of age or older) were assisted in deplaning by male passengers and flight attendants (FAA report).

13. NTSB-1-0001, Nantucket, Massachusetts, November 4, 1970. A flight attendant reported difficulty in evacuating a passenger who had been injured when the plane encountered clear air turbulence (FAA report).

14. NTSB-1-0042, February 12, 1971. A passenger who had required assistance in boarding fell during turbulence enroute and broke an ankle (FAA report).

15. NTSB-1-0008, Philadelphia, Pennsylvania, February 25, 1970. A 78-yr-old female passenger fell when the aircraft encountered light turbulence and broke her hip (FAA report).

16. NTSB-1-0019, Cleveland, Ohio, February 26, 1970. A 65-yr-old female fell down the stairs during normal deplaning and broke her hip (FAA report).

17. NTSB Docket No. A-60, Hilo, Hawaii, February 13, 1964. An elderly couple and an infant were observed to delay the evacuation of a flight arriving at Hilo, Hawaii, and an elderly female passenger (deplaned by stretcher) was not removed from the aircraft until 18 min had elapsed.

18. NTSB-1-0031, Denver, Colorado, September 8, 1967. A flight attendant had to assist an elderly male passenger, and the captain had to persuade an elderly female passenger to deplane after she had refused to move.

19. NTSB-1-0048, Chicago, Illinois, December 8, 1972. A 63-yr-old hemiplegic female passenger boarded by forklift, a 38-yr-old male passenger with an ankle cast, and an 8-mo-old baby were fatalities as the result of the aircraft's impact with several houses and the ensuing fire (human factors report).

20. NTSB-1-0070, North Canton, Ohio, December 11, 1967. The captain and first officer each had to assist an elderly female passenger in evacuating the aircraft. The passenger assisted by the captain was the last to leave the aircraft.

21. NTSB-1-0057, Jamaica, New York, June 3, 1968. The captain assisted the last passenger, an elderly female, from the aircraft.

22. NTSB-NE-515, Sidney, Australia, December 1, 1969. The rear galley exit of an aircraft was blocked by a 96-yr-old blind crippled female and her 76-yr-old son, neither of whom spoke English. The woman refused to enter the slide but was eventually forced onto the slide by a flight attendant and the son. They were the only people to use that exit.

23. NTSB-SA-369, Denver, Colorado, July 11, 1961. An elderly, paraplegic male passenger, traveling with his wife, had to be carried off the aircraft by the flight engineer (not documented).

24. NTSB-1-0070, Washington, D.C., February 13, 1960. A female passenger in her 60's (boarded by wheelchair) and another with braces on both legs and walking with crutches slowed the evacuation of the aircraft.

25. NTSB-1-0015, Jamaica, New York, February 3, 1964. An air safety investigator observed a DC-8 evacuation that required 3 to 4 min. The total number evacuated is not mentioned, but it is known that three women (two of them elderly) and a baby were evacuated, at their leisure, after it had been determined that fire was not a problem.

26. NTSB-1-0037, Boston, Massachusetts, August 7, 1968. At least three elderly passengers required crew assistance to evacuate the aircraft.

27. NTSB-1-0022, Raleigh, North Carolina, November 13, 1975. An evacuation was observed by a cabin attendant to have gone smoothly, taking approximately 40 s to complete. One male passenger, in the left aisle seat three rows forward of the aft left exit, was a paraplegic. He was carried to the aft right exit by passengers who used his arms (near the shoulders) as carrying points. He was placed onto the slide and traversed its length in a headfirst, belly-down attitude. At the bottom of the slide, he received an upper internal lip contusion (no hospitalization was required). A 66-yr-old female, while not handicapped by her age, was incapacitated after leaving the aircraft when someone jumped on and broke her ankle. One passenger (a "dead-head" cabin attendant) suffered a reinjury of her shoulder while attempting to remove an overwing exit plug. Her cast had been off for only 2 weeks.

28. NTSB-1-0011, Philadelphia, Pennsylvania, June 23, 1976. At approximately 1712 EDT, Flight 121 (a DC-9-30) carrying 106 occupants crashed while attempting a go-around maneuver. The crash impact imposed severe downward loading on the occupants and the aircraft seating and the following injuries resulted.

Captain:	Multiple spinal fractures, contusions and lacerations of the forehead and left temple, and rib fractures.
First Officer:	Multiple spinal fractures, contusions, a lacerated tongue, and abrasions of both legs.
Cabin Attendant A:	Compression-type spinal fracture.

Cabin Attendant B: Left ankle and left leg contusion, acute lumbosacral and cervical strains, and a lacerated tongue.

Twenty passengers received no injuries at all. Fifty sustained injuries to include cervical and lumbosacral strains and sprains, whiplashes, facial lacerations, tongue lacerations, broken teeth, and multiple contusions and abrasions to the head/face and extremities. Thirty-two passengers sustained the following serious injuries in addition to the injuries listed above: 7 cervical fractures, 8 thoracic fractures, 11 lumbar fractures, 1 ankle fracture, and 2 arm fractures. Of the 102 passengers aboard, 84 were adult males, 14 were adult females, and 4 were children. One adult male was 76 yr old and one was 83 yr old. One adult female was 73 yr old and one was a pregnant 26 yr old. The children were 3 yr, 2 yr, 21 mo, and 6 mo of age. None of the passengers was listed as being handicapped or in need of special handling.

The nature of this accident is odd in that no fatalities occurred even though many of the resulting injuries were extremely severe.

29. DCA 76AZ024, Ketchikan, Alaska, April 5, 1976. At approximately 0820 PDT, Flight 60 (a B-727-81) with 43 passengers and 7 crewmembers, crashed off the departure end of Runway 11. The fuselage went over a steep embankment, broke in three places, and burned. Thirty-four occupants were injured, eleven seriously. Fifteen occupants, including two infants, were not injured. The only fatality was an 85-yr-old female who died of massive head injuries.

Included in the 43-member passenger population were the following: one 62-yr-old female (boarded in a wheeled aisle chair) who was recovering from rectal surgery; one elderly couple, each more than 60 yr of age, each of whom had a heart problem; one 85-yr-old female who required no assistance (fatality); one 3-yr-old female; and 2 infants (nonticketed).

It should be noted that each of the four elderly passengers requested wheelchair assistance at his/her destination because of the airport's size and the need to make connecting flights.

The elderly couple had to be assisted in that the wife was unable to release her husband's seatbelt because his seat had inverted and his entire weight was on the belt. A female had to be assisted in evacuating with her 3-yr-old and infant daughter. Several of the passengers and crewmembers had to be assisted in evacuating the aircraft because spinal injuries received during impact precluded their walking.

APPENDIX B

SUBJECT DATA

Age	Weight (lb)	Height (in)	Sex	Affliction(s)
22	110	62	M	Cerebral palsy
27	120	60	F	Cerebral palsy*
67	130	63	F	Arthritis
39	120	61	F	Polio
19	120	67	M	Paraplegia*
73	106	67	F	Elderly
22	130	66	F	Blind
24	226	63	M	Mental deficiency
35	175	69	M	Paraplegia*
47	180	71	M	Cast (lower leg)
38	220	71	M	Quadriplegia
52	182	73	M	Multiple sclerosis
26	170	76	M	Mental deficiency
36	154	62	F	Polio
33	75	53	F	Arthritis (crippling)
45	110	61	M	Paraplegia
15	119	68	F	Mental deficiency
84	143	65	M	Elderly
51	95	61	M	Birth defects
51	155	69	M	Paraplegia
60	120	64	F	Partially sighted
58	170	72	M	Blind
35	190	64	F	Blind
68	225	73	M	Blind
27	220	62	F	Blind
24	120	64	F	Blind
27	190	61	M	Blind
56	175	70	M	Blind
28	150	61	F	Paraplegia
41	155	65	M	Cerebral palsy*
71	210	73	M	Blind, senile
32	175	72	M	Cerebral palsy
63	178	70	M	Elderly
76	142	71	M	Hemiplegia
46	215	74	M	Blind
24	140	63	M	Paraplegia*
27	125	64	F	Mental deficiency
53	155	65	M	Polio
21	160	49	F	Cerebral palsy
25	165	48	F	Mental deficiency
26	165	69	M	Mental deficiency
25	115	60	M	Paraplegia

*Requires wheelchair

Age	Weight (lb)	Height (in)	Sex	Affliction(s)
55	190	72	M	Deaf mute
39	220	72	M	Congenital birth defect
15	100	63	M	Paraplegia
80	153	69	F	Elderly
55	160	73	M	Elderly (physically)
42	179	66	M	Blind (legally)
64	112	64	F	Hemiplegia
25	140	63	M	Blind
57	185	72	M	Partially sighted
33	220	74	M	Blind
35	185	53	F	Blind
68	180	72	M	Elderly
22	180	72	M	Blind
58	195	72	M	Partially sighted
47	155	66	M	Partially sighted
31	215	64	M	Mental deficiency
18	110	55	F	Cerebral palsy
22	160	68	M	Muscular dystrophy
19	115	59	M	Mental deficiency
19	125	59	M	Spastic quadriplegia
	126	58	F	Deaf
45	120	65	M	Arthritis, right leg short from fracture
	114	59	F	Deaf
			F	Fractured left elbow
			M	Crushed humerus, condyle
31	170	67	F	Hemiplegia (aneurysm)
54	210	65	F	Obesity
69	150	65	M	Hemiplegia (stroke)
56	160	65	M	Hemiplegia (stroke)
			M	Lower right leg amputee
48	220	60	F	Obesity
41	215	58	F	Obesity
78	130	63	F	Hemiplegia (stroke)
65			M	Hemiplegia (stroke)
68	125	64	F	Elderly
73	195	61	M	Elderly
32	175	72	M	Cerebral palsy
63	178	70	M	Elderly
76	142	71	M	Hemiplegia
22	130	66	F	Blind
52	182	73	M	Multiple sclerosis
51	155	69	M	Paraplegia
64	112	64	F	Hemiplegia
60	120	64	F	Partially sighted
68	180	72	M	Elderly
28	150	61	F	Paraplegia
14	110	60	M	Left forearm in cast

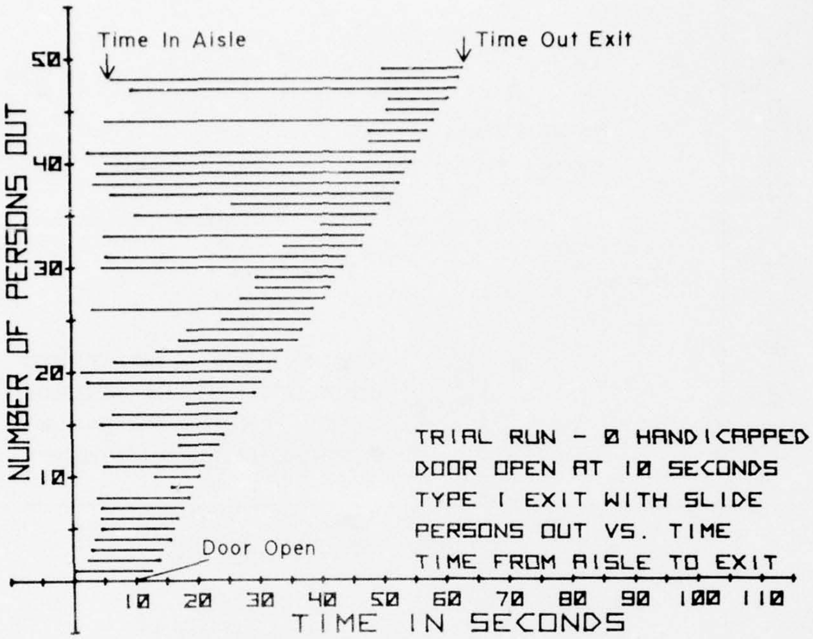
Age	Weight (lb)	Height (in)	Sex	Affliction(s)
20	120	65	F	Normal simulated blind
17	115	68	F	Normal simulated blind
38	180	70	M	Normal simulated blind
38	163	68	M	Normal simulated blind
47	185	67	M	Normal simulated blind
55	248	70	M	Normal simulated blind
21	155	67	F	Normal simulated blind
50	198	72	M	Normal simulated blind
34	180	71	M	Normal simulated blind
42	221	72	M	Normal simulated blind
64	132	63	F	Normal simulated blind
30	135	66	F	Normal simulated blind
20	140	67	F	Normal simulated blind
44	180	69	M	Normal simulated blind
44	173	71	M	Normal simulated blind
42	150	65	F	Normal simulated blind
42	158	72	M	Normal simulated blind
17	115	67	F	Normal simulated blind
44	161	72	M	Normal simulated blind
53	135	67	M	Normal simulated blind
38	240	73	M	Normal simulated blind
26	135	67	M	Normal simulated blind
80	145	68	F	Broken hip with poor mend: arthritis
60	128	64	F	Hemiplegia
68	118	65	F	Hemiplegia
70	165	71	M	Congenital hip, neck deformity
22	160	68	M	Muscular dystrophy
19	115	59	M	Mental deficiency
68	169	68	M	Elderly
66	170	70	M	Lower leg amputee (single)
67	145	66	M	Mental deficiency, senility
77	143	64	M	Mental deficiency
31	100	64	F	Depression
41	220	71	M	Congenital birth defects
59	147	68	M	Hemiplegia
79	130	63	F	Hemiplegia
66	108	61	F	Hemiplegia
57	216	64	F	Obesity
47	100	61	F	Mental deficiency
31	200	72	M	Mental deficiency
33	96	59	F	Mental deficiency, crossed eyes
32	80	59	F	Prelingually deaf
47	190	69	M	Partially sighted
47	175	70	M	Multiple sclerosis
23	152	66	F	Slight mental deficiency
22	120	67	F	Cerebral palsy, deafness
58	101	65	F	Partially sighted
53	125	61	M	Birth defects

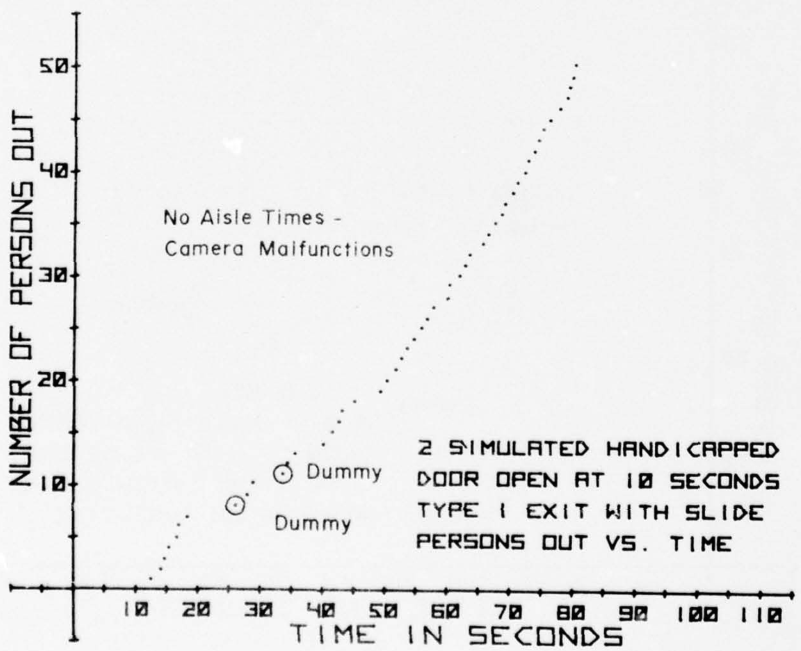
Age	Weight (lb)	Height (in)	Sex	Affliction(s)
60	160	60	F	Schizophrenia
61	187	64	F	Depression
60	115	62	F	Mental deficiency
61	145	62	F	Schizophrenia
60	135	53	F	Mental deficiency
21	155	67	F	Normal (speed run)
54	161	66	M	Normal (speed run)
25	135	64	F	Mental deficiency
56	170	71	M	Prematurely aging
55	112	63	F	Cerebral palsy
64	140	66	F	Multiple sclerosis
60	163	74	M	Hemiplegia
53	155	69	M	Paraplegia
15	135	60	M	Paraplegia
48	207	68	M	Paraplegia
24	125	66	M	Paraplegia
23	110	52	F	Paraplegia
26	96	64	M	Paraplegia
45	105	62	F	Paraplegia
21	220	59	F	Paraplegia
21	150	59	F	Paraplegia
19	124	52	M	Paraplegia
60	160	60	F	Schizophrenia
61	187	64	F	Depression
60	115	62	F	Mental deficiency
61	145	62	F	Schizophrenia
60	135	53	F	Mental deficiency
53	155	69	M	Paraplegia*
66	170	70	M	Lower leg amputee (single)
47	190	69	M	Partially sighted

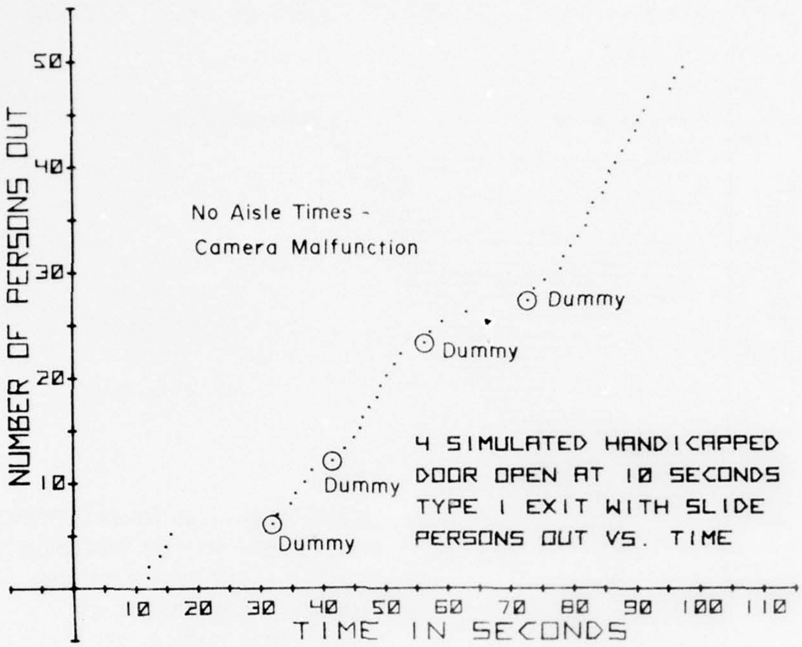
*Requires wheelchair

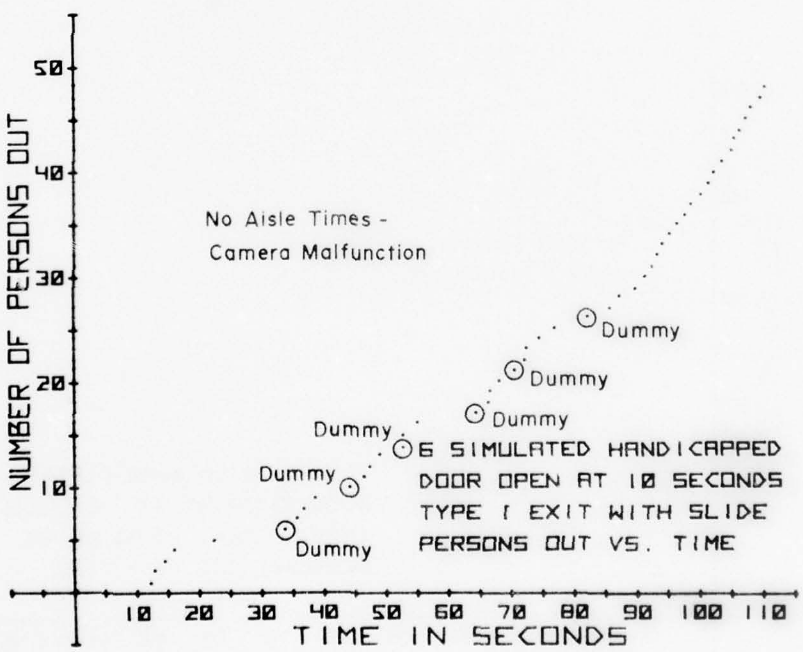
APPENDIX C

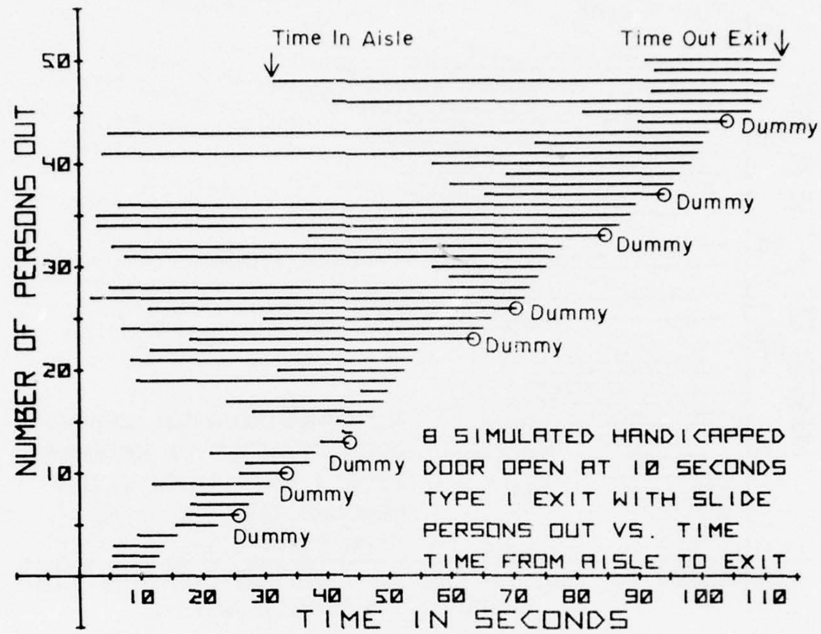
CHARTS AND GRAPHS OF EVACUATION TIMES OF GROUP STUDIES

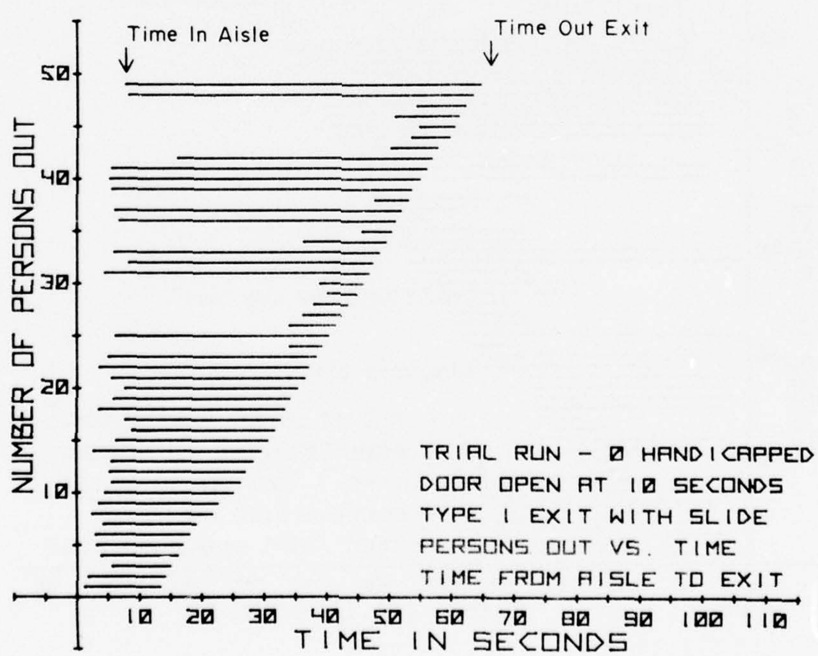


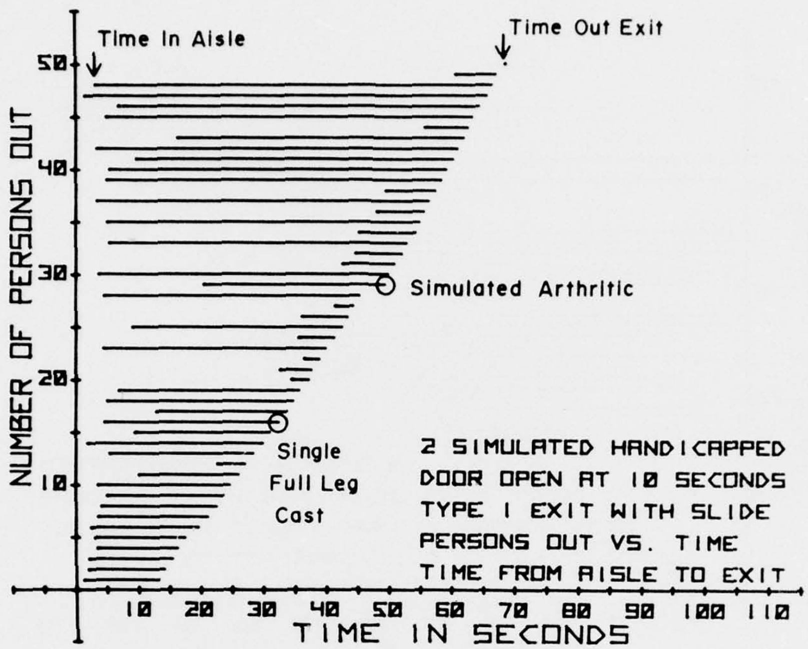


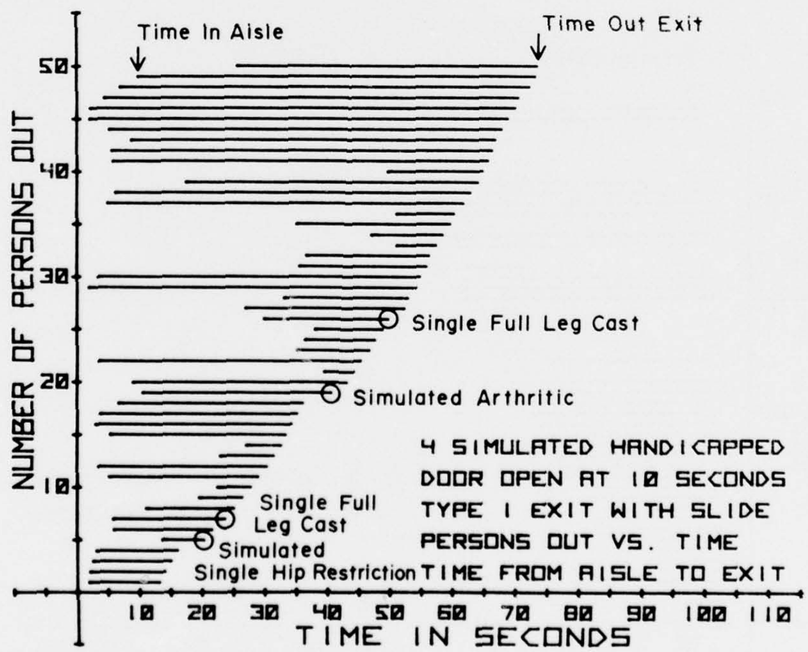

NUMBER OF PERSONS OUT
TIME IN SECONDS
No Aisle Times -
Camera Malfunction
Dummy
Dummy
Dummy
Dummy
4 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME

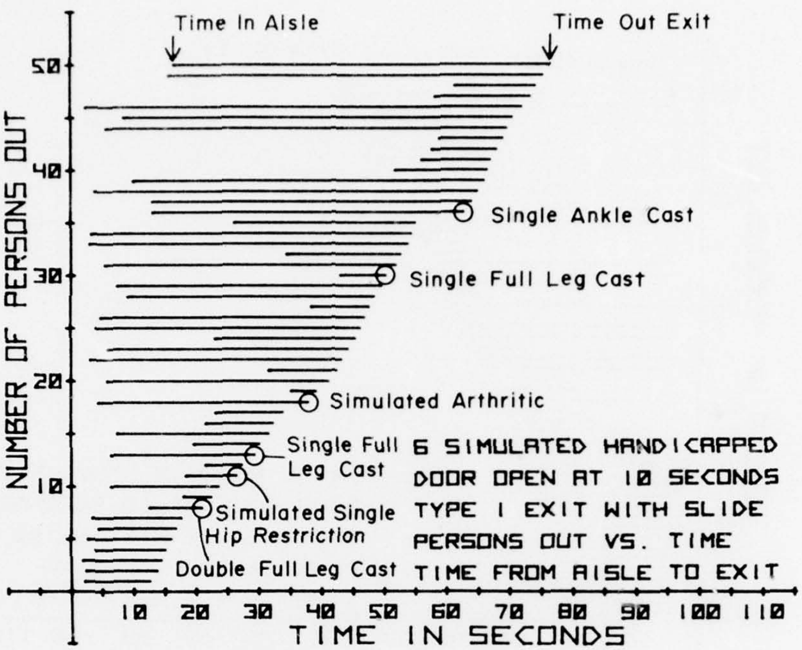

NUMBER OF PERSONS OUT
TIME IN SECONDS
No Aisle Times -
Camera Malfunction
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
6 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME

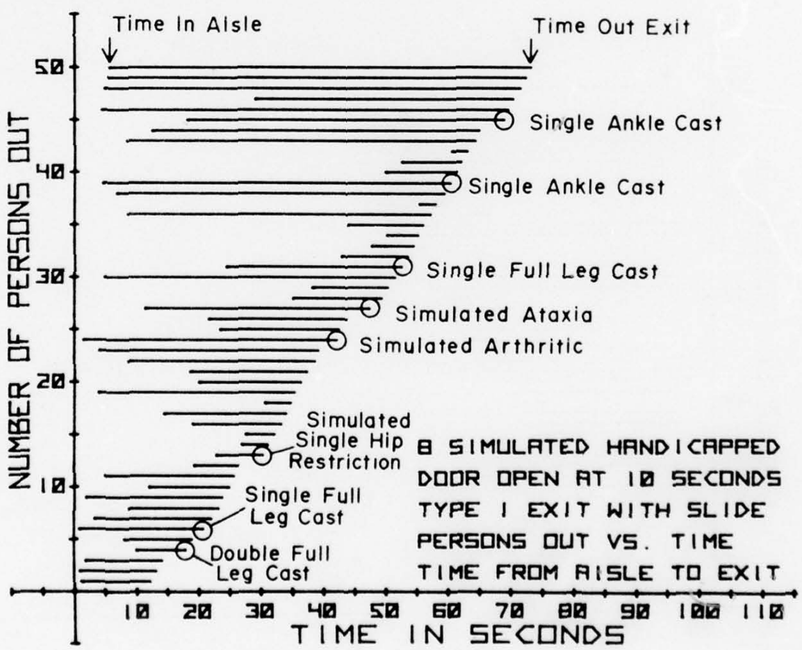

Time In Aisle
Time Out Exit
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
8 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS

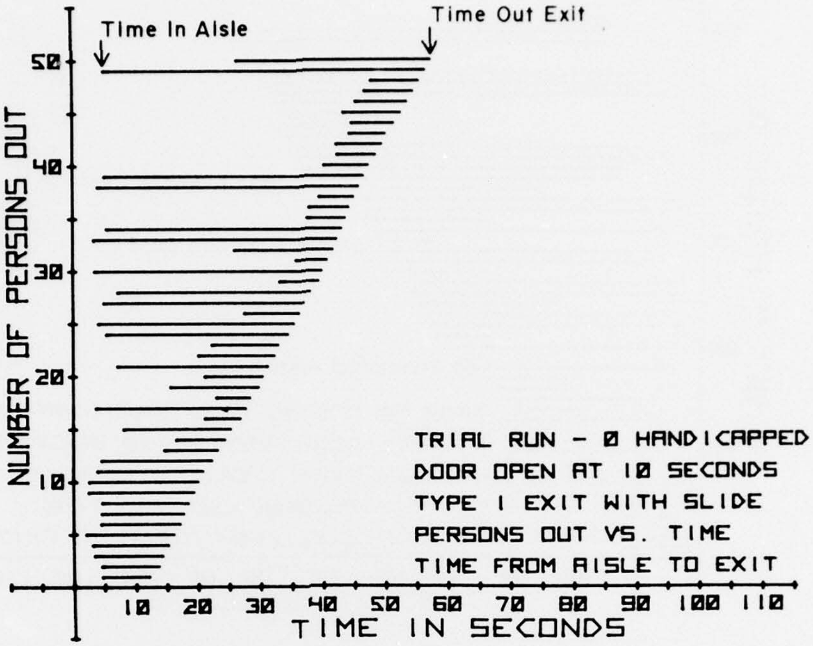

Time In Aisle
Time Out Exit
TRIAL RUN - 0 HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS

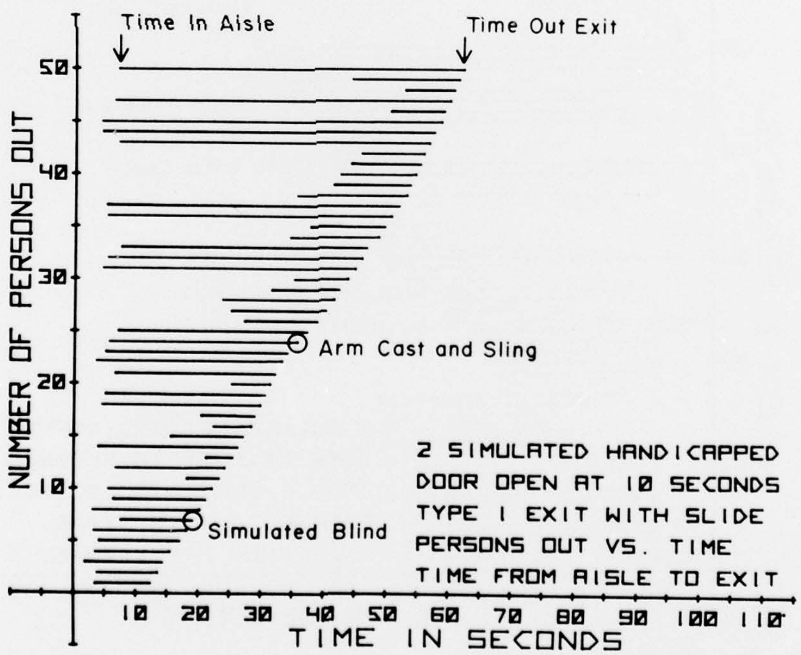

Time In Aisle
Time Out Exit
Simulated Arthritic
Single
Full Leg
Cast
2 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
10
20
30
40
50
60
70
80
90
100
110
TIME IN SECONDS

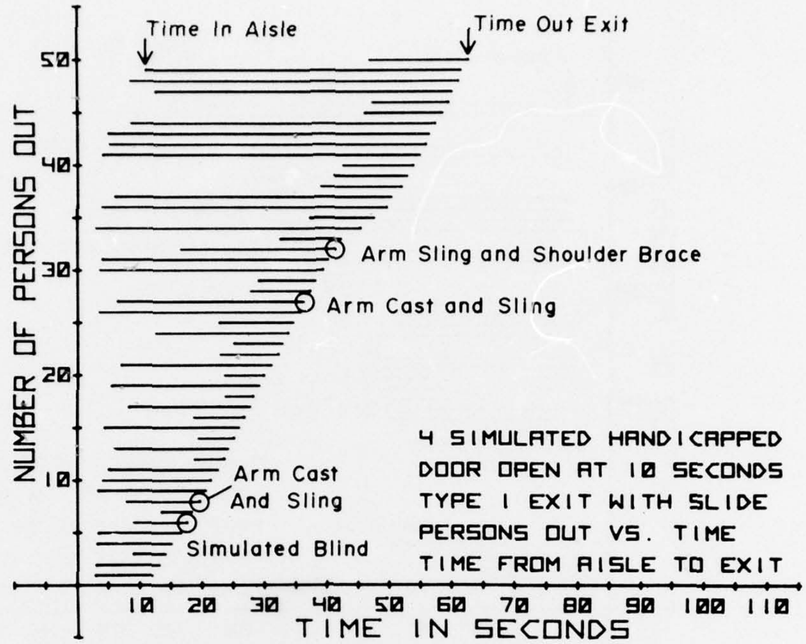

Time In Aisle
Time Out Exit
Single Full Leg Cast
Simulated Arthritic
4 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
Single Full
Leg Cast
Simulated
Single Hip Restriction
NUMBER OF PERSONS OUT
10
20
30
40
50
60
70
80
90
100
110
TIME IN SECONDS

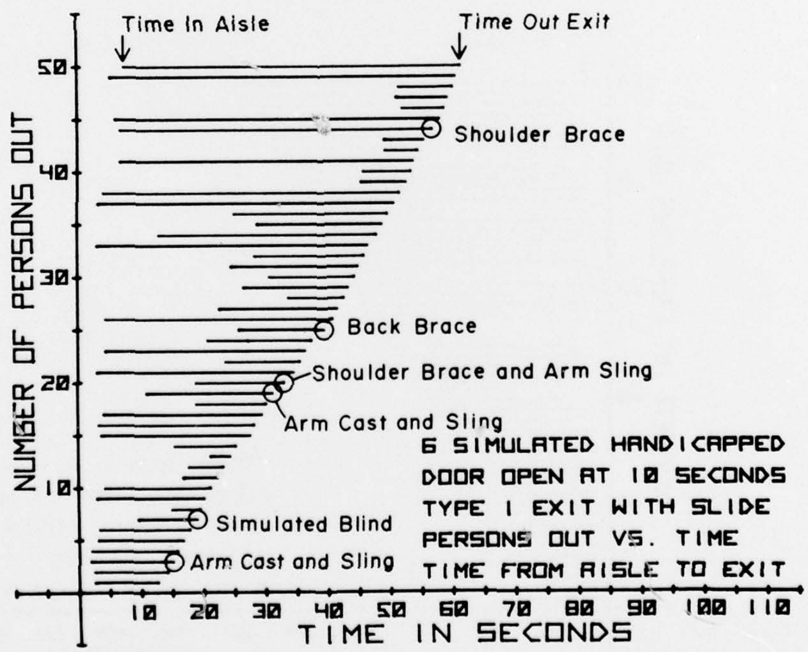

Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
50
40
30
20
10
Single Ankle Cast
Single Full Leg Cast
Simulated Arthritic
Single Full Leg Cast
Simulated Single Hip Restriction
Double Full Leg Cast
6 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS

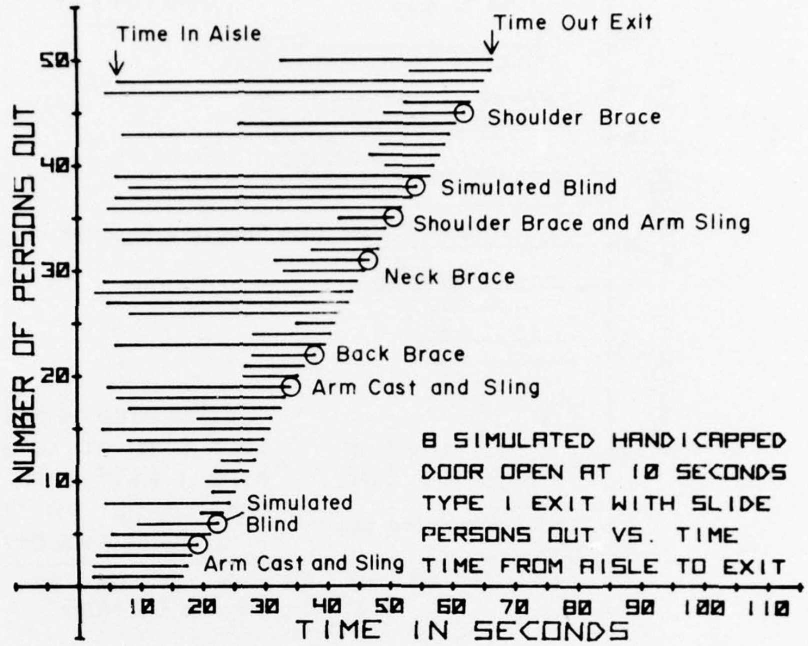

Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
50
40
30
20
10
Single Ankle Cast
Single Ankle Cast
Single Full Leg Cast
Simulated Ataxia
Simulated Arthritic
Simulated Single Hip Restriction
Single Full Leg Cast
Double Full Leg Cast
8 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS


Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
10
20
30
40
50
TRIAL RUN - 0 HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS

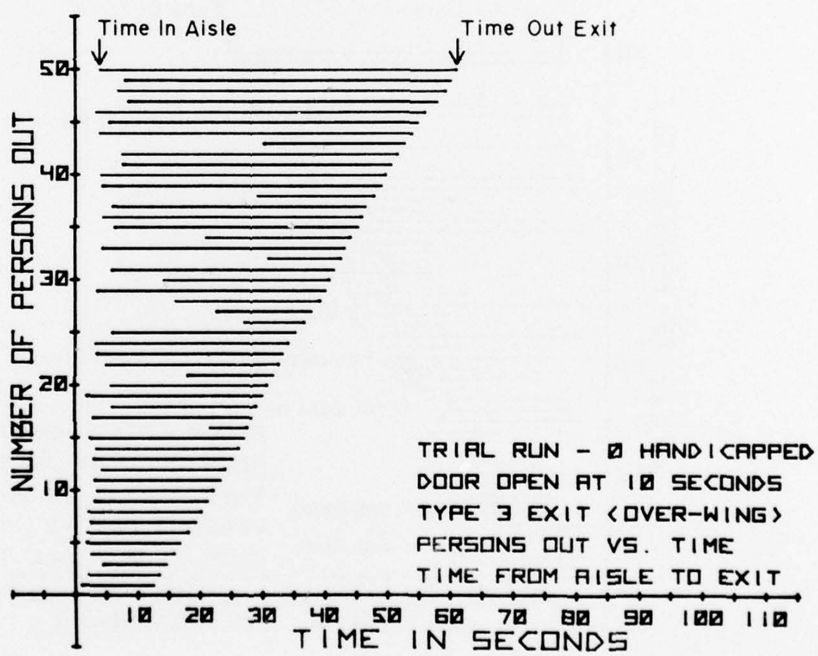

Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
10
20
30
40
50
Arm Cast and Sling
Simulated Blind
2 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS


Time In Aisle
Time Out Exit
Arm Sling and Shoulder Brace
Arm Cast and Sling
Arm Cast And Sling
Simulated Blind
4 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS

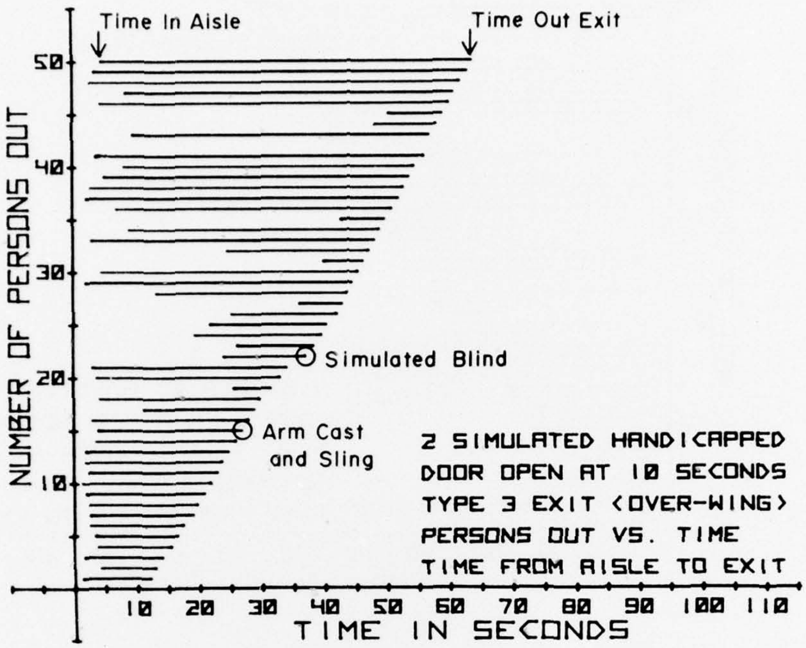

Time In Aisle
Time Out Exit
Shoulder Brace
Back Brace
Shoulder Brace and Arm Sling
Arm Cast and Sling
Simulated Blind
Arm Cast and Sling
6 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS



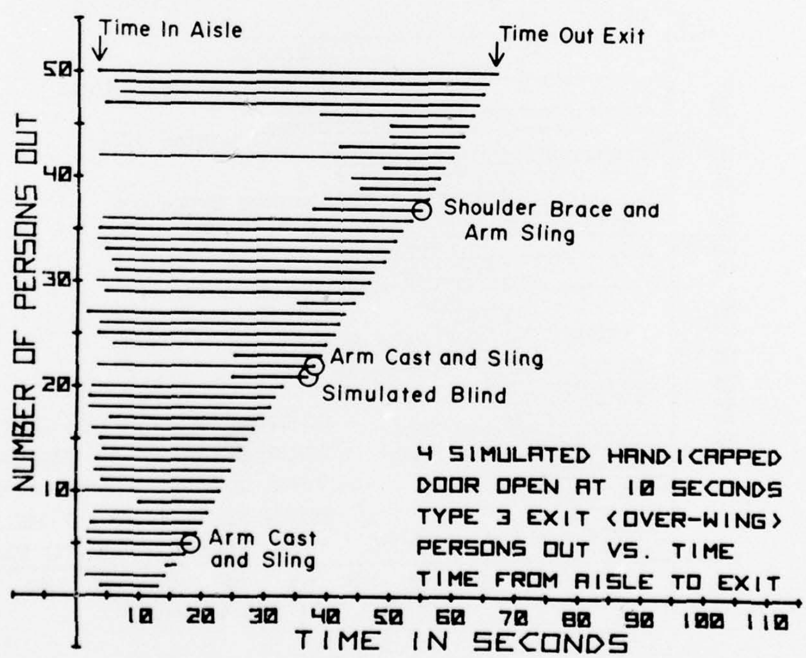
Time In Aisle
Time Out Exit
Shoulder Brace
Simulated Blind
Shoulder Brace and Arm Sling
Neck Brace
Back Brace
Arm Cast and Sling
Simulated
Blind
Arm Cast and Sling
8 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE I EXIT WITH SLIDE
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS



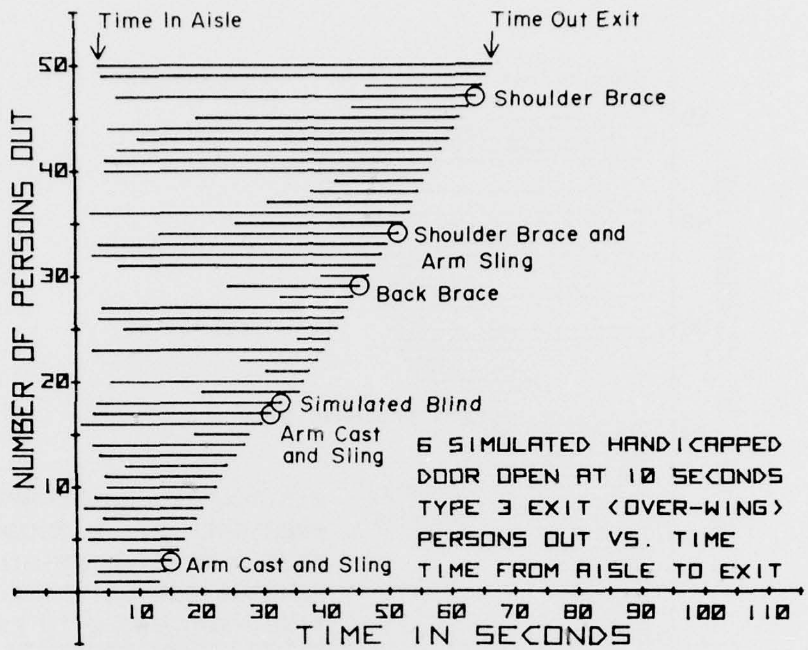
Time In Aisle
Time Out Exit
TRIAL RUN - 0 HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS

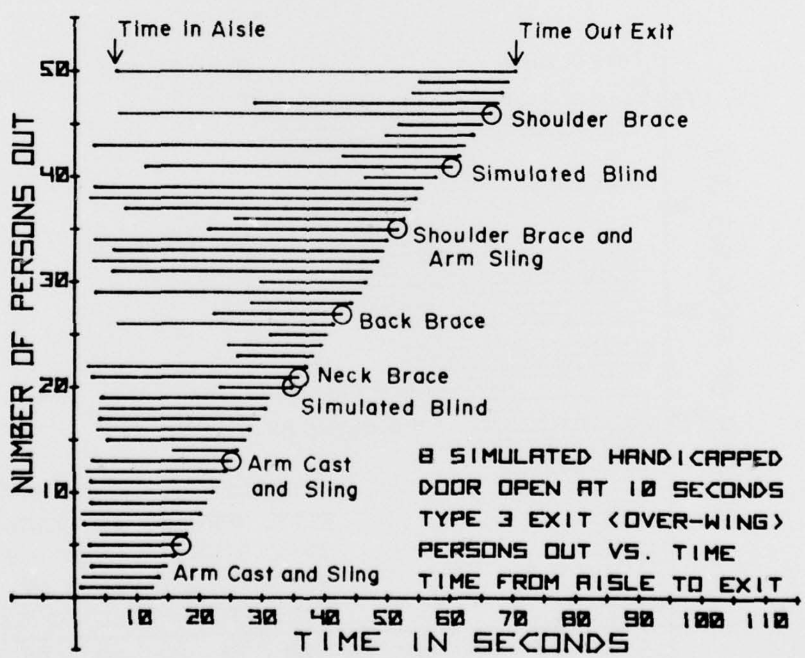


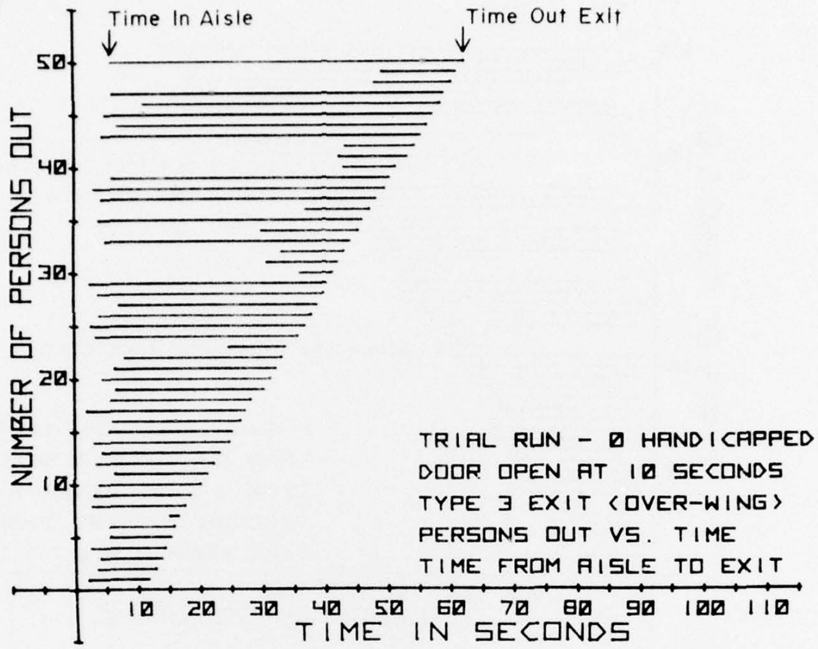
Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
Simulated Blind
Arm Cast and Sling
2 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
TIME IN SECONDS

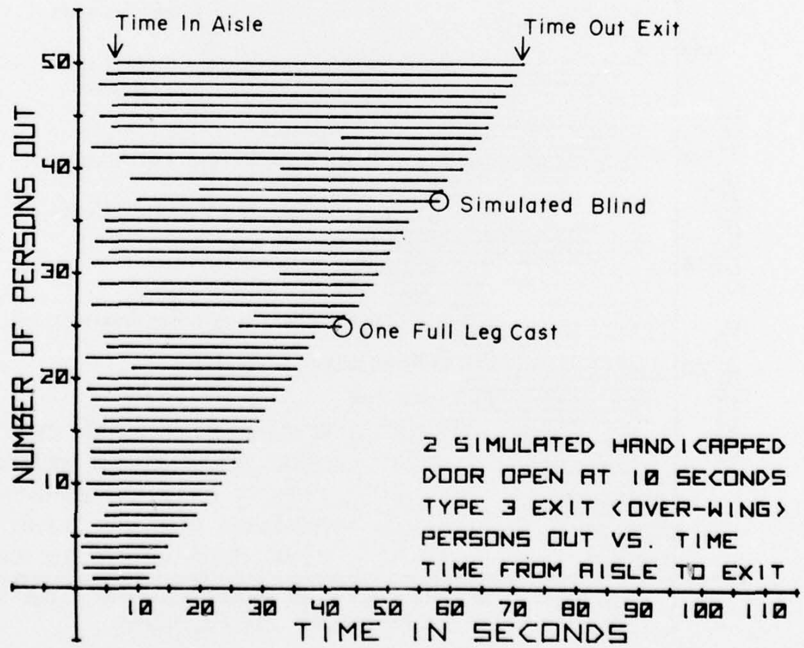


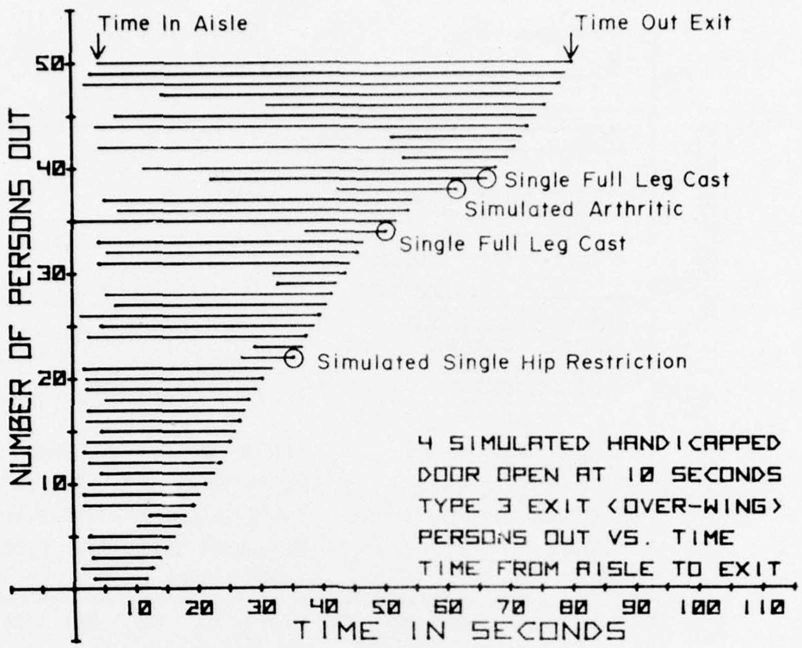
Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
Shoulder Brace and Arm Sling
Arm Cast and Sling
Simulated Blind
Arm Cast and Sling
4 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
TIME IN SECONDS

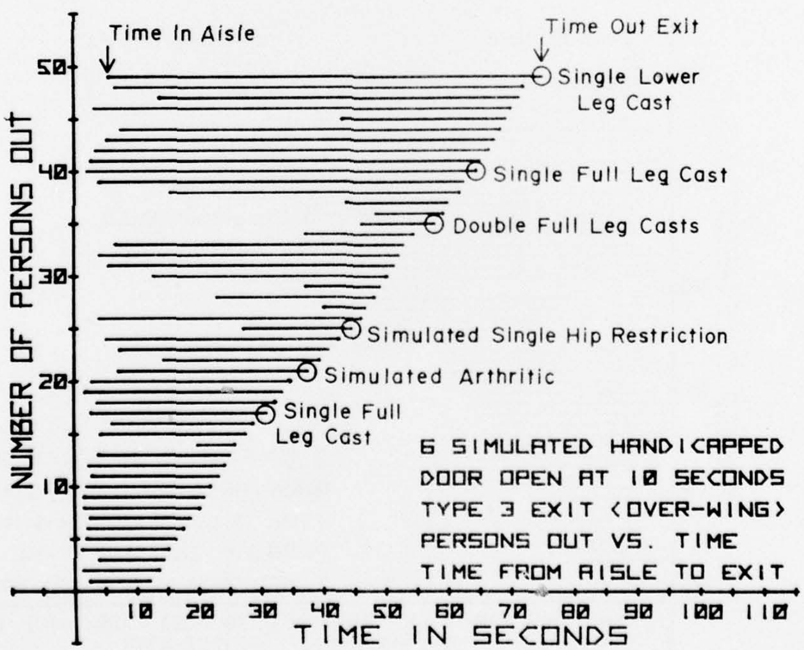

Time In Aisle
Time Out Exit
Shoulder Brace
Shoulder Brace and Arm Sling
Back Brace
Simulated Blind
Arm Cast and Sling
Arm Cast and Sling
6 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT <OVER-WING>
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
10
20
30
40
50
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS

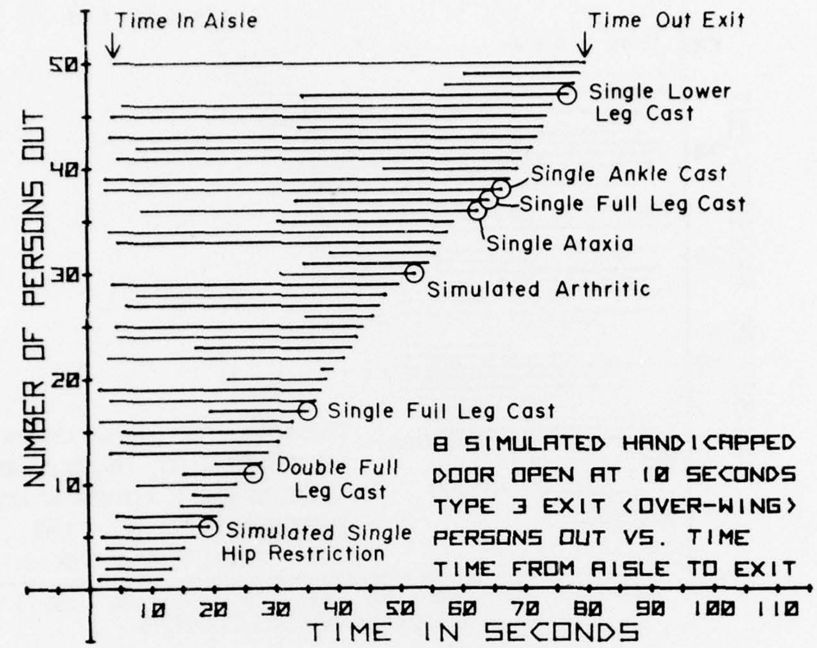

Time In Aisle
Time Out Exit
Shoulder Brace
Simulated Blind
Shoulder Brace and Arm Sling
Back Brace
Neck Brace
Simulated Blind
Arm Cast and Sling
Arm Cast and Sling
8 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT <OVER-WING>
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
10
20
30
40
50
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS

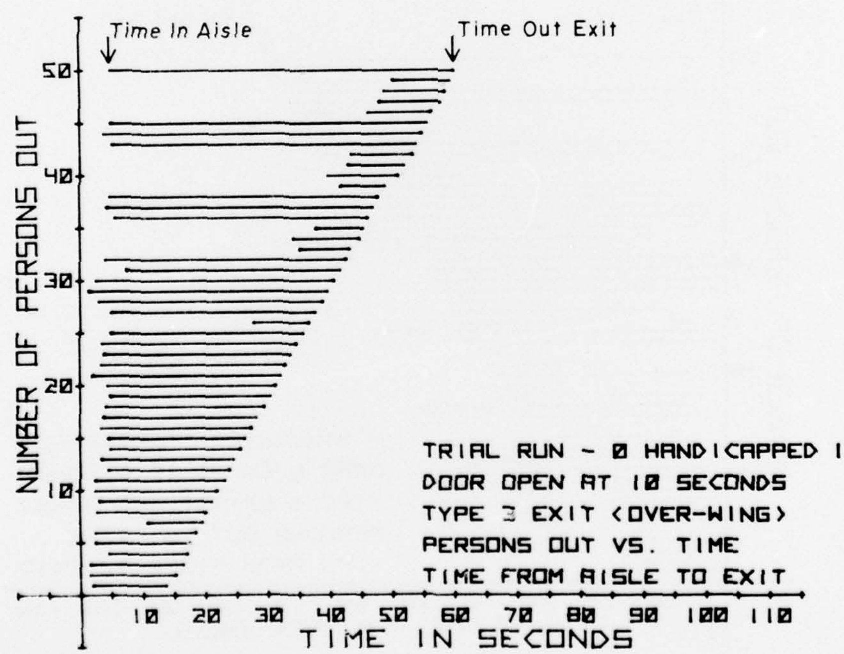

Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
50
40
30
20
10
TRIAL RUN - 0 HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS

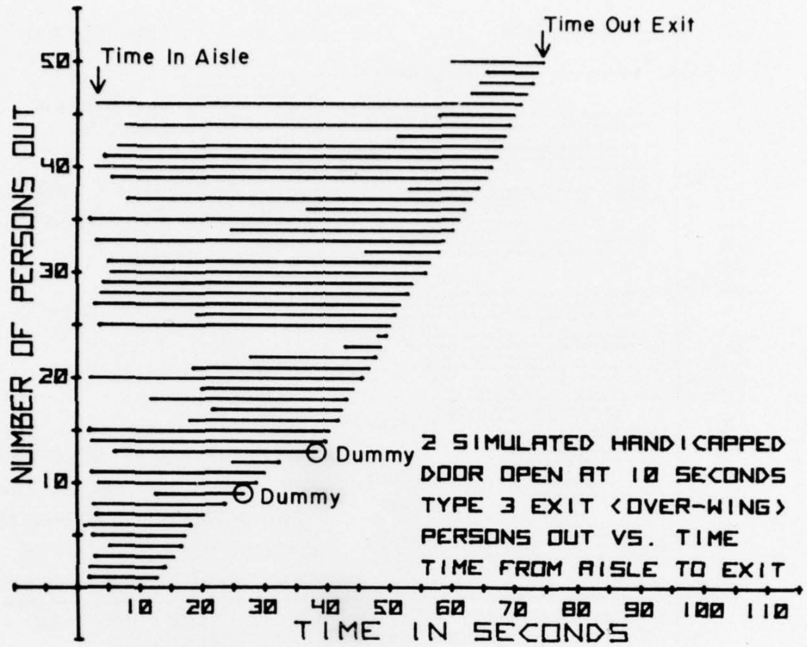

Time In Aisle
Time Out Exit
Simulated Blind
One Full Leg Cast
NUMBER OF PERSONS OUT
50
40
30
20
10
2 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS


Time In Aisle
Time Out Exit
Single Full Leg Cast
Simulated Arthritic
Single Full Leg Cast
Simulated Single Hip Restriction
4 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
10
20
30
40
50
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS

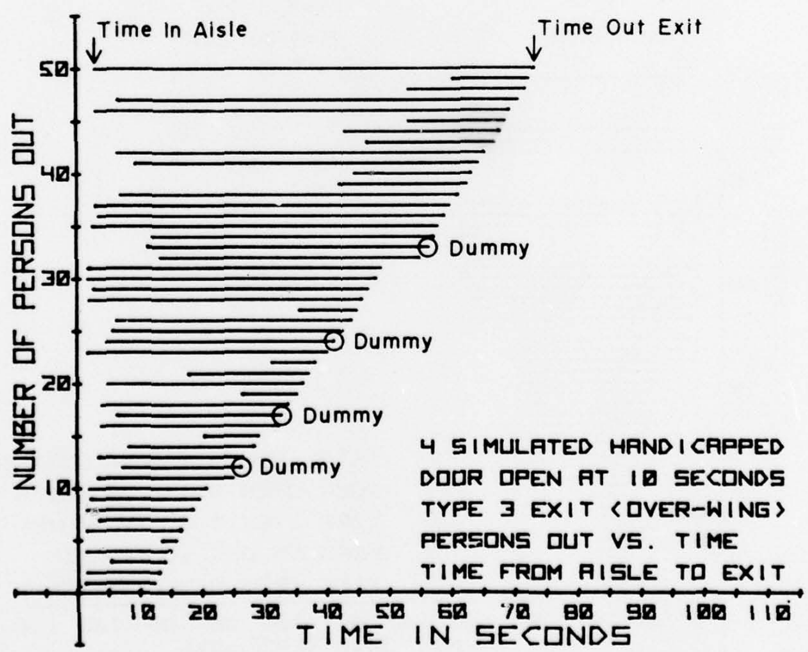

Time In Aisle
Time Out Exit
Single Lower Leg Cast
Single Full Leg Cast
Double Full Leg Casts
Simulated Single Hip Restriction
Simulated Arthritic
Single Full Leg Cast
6 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
10
20
30
40
50
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS


Time In Aisle
Time Out Exit
Single Lower Leg Cast
Single Ankle Cast
Single Full Leg Cast
Single Ataxia
Simulated Arthritic
Single Full Leg Cast
Double Full Leg Cast
Simulated Single Hip Restriction
8 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS
10 20 30 40 50
10 20 30 40 50 60 70 80 90 100 110

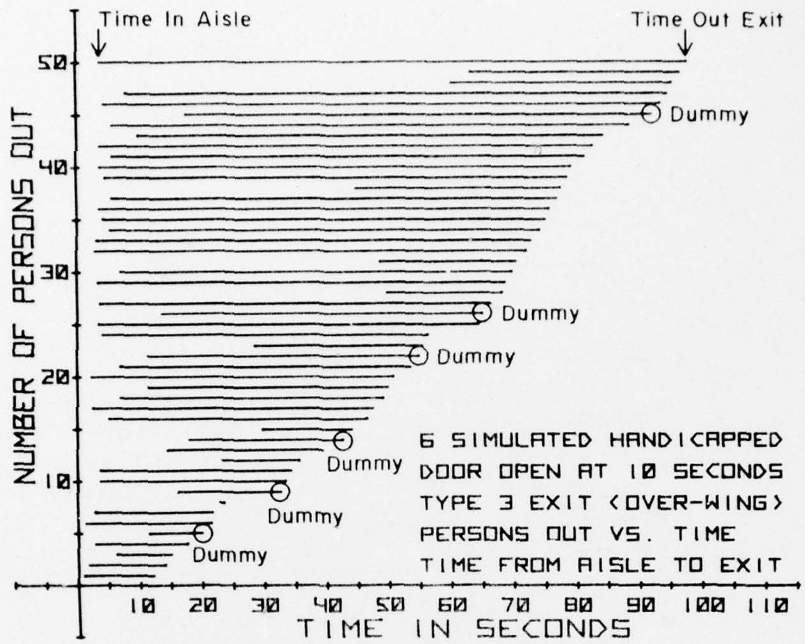

Time In Aisle
Time Out Exit
TRIAL RUN - 0 HANDICAPPED I
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS
10 20 30 40 50
10 20 30 40 50 60 70 80 90 100 110



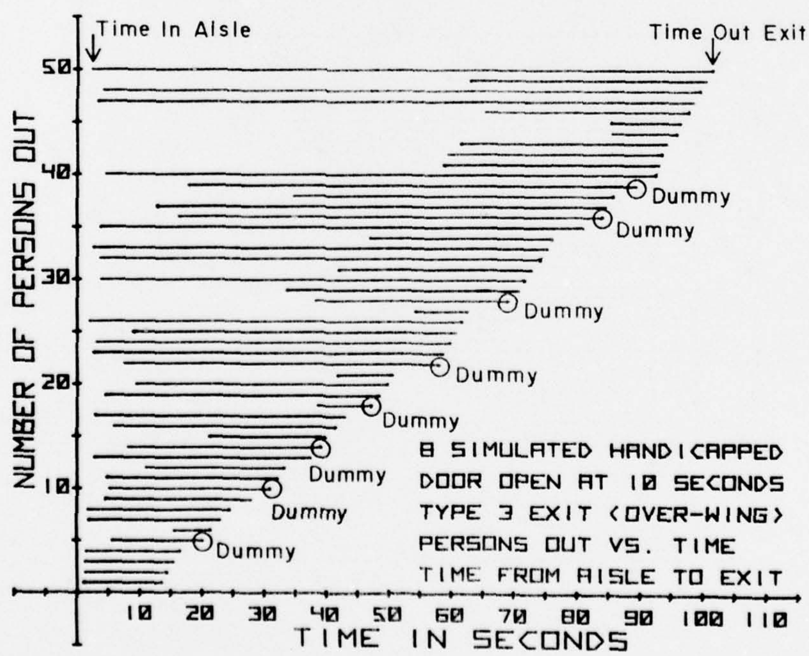
Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
50
40
30
20
10
Dummy
Dummy
2 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT <OVER-WING>
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS



Time In Aisle
Time Out Exit
NUMBER OF PERSONS OUT
50
40
30
20
10
Dummy
Dummy
Dummy
Dummy
4 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT <OVER-WING>
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
10 20 30 40 50 60 70 80 90 100 110
TIME IN SECONDS



Time In Aisle
Time Out Exit
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
6 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS



Time In Aisle
Time Out Exit
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
Dummy
8 SIMULATED HANDICAPPED
DOOR OPEN AT 10 SECONDS
TYPE 3 EXIT (OVER-WING)
PERSONS OUT VS. TIME
TIME FROM AISLE TO EXIT
NUMBER OF PERSONS OUT
TIME IN SECONDS

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APPENDIX D

RESULTS OF SURVEY OF HANDICAPPED TEST SUBJECTS*

The blind had the most flight experience. Twelve of their number had flown more than twice and one had flown 25 times in the 5 yr preceding the interview. Mentally retarded subjects had the least flight experience.

The results of the survey can be summarized:

a. Ninety-five percent of the mentally retarded subjects and 80 percent of the hemiplegic subjects travel with companions.

b. Sixty-five percent of the handicapped subjects preferred to be guided when assistance was available. The term "guided" included specific directional oral commands.

c. Sixteen percent of the handicapped subjects preferred some physical support, such as leading.

d. Nine percent of the subjects would prefer to be carried in an emergency evacuation.

e. Six percent of the subjects would prefer to be dragged in an emergency evacuation.

f. Five percent of the subjects would prefer to be pulled in the upright position in an emergency evacuation. Pulling is similar to supportive leading except it is done more to facilitate a speeding of movement than to provide support.

g. Seventy-three percent of the subjects felt they could walk without support.

h. Twenty-seven percent required some means of support to walk.

i. Twenty-eight percent required wheelchairs at least part of the time.

j. Ten percent required crutches.

k. Eight percent required canes.

l. Two percent required quadrupeds (four-footed canes).

Because of their greater air travel experience, the blind subjects were better able to evaluate and suggest ways of improving passenger flight. Most

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*Comments contained in this Appendix were obtained from the test subjects who participated in this study; they do not necessarily reflect the results of the study or the recommendations of the authors.

other handicapped subjects, however, had some suggestions for improvement. The following suggestions and ideas were offered by blind and paraplegic subjects:

a. Blind Subjects.

1. Assistance to blind passengers is more important on the ground than in flight.

2. The general policy of some airlines and airports that any passenger with a physical impairment must be taken to the aircraft from the terminal by wheelchair causes unnecessary embarrassment for blind passengers.

3. A blind passenger can generally travel alone without problems; however, a timid blind passenger should travel with a companion.

4. Special seating for the blind is not necessary, but seats in the general vicinity of normal exits are desirable.

5. As many as four blind persons could be seated together.

6. The captain should relay any pertinent information regarding the flight, such as weather, change of course, entry into a holding pattern, abrupt changes in aircraft noises, and similar occurrences.

7. An information card printed in Braille, or taped emergency procedures included with the stereo music, would be beneficial.

8. Exit and lavatory locations should be marked with an audible tone or described orally.

9. Mockup emergency equipment such as oxygen masks would aid in familiarization of blind passengers with the use of that equipment.

10. In an emergency, sighted passengers could do much to relieve apprehension of blind passengers by providing descriptions of conditions and changes in the environment.

11. The best guidance would be that provided by sighted passengers moving to exits.

12. Speed on the slide might be controlled by a rope attached to each passenger.

13. Any physical contact by a helper while the blind passenger is on the slide would interfere with the power of concentration needed to judge ground contact.

14. Handicapped persons should be present during training programs for crewmembers to provide firsthand information and advice.

b. Paraplegic Subjects.

1. Minimum aisle width should be sufficient to allow wheelchairs in the main aisle.

2. Aisle armrests should be removable to facilitate transfer of passengers from wheelchairs to these seats.

3. Some type of covering should be placed on slides to prevent friction burns.

4. Handicapped passengers should always start down the slide from a sitting position.

5. A simple leg strap should be provided to prevent legs from spreading during slide descent.

6. Handholds or ropes could be provided on slides to enable paraplegics and others to control descent.

7. A restraint harness for severely disabled passengers should be available to lower them down the slide at a safe speed.

8. Articles on emergency evacuation of handicapped passengers should be submitted for inclusion in the literature of organizations of handicapped persons.

Arthritic subjects said that seatbelt buckles should be designed so they could be opened more easily by passengers with hand impairments. Obese subjects stated that seats should be wider to accommodate larger passengers.

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APPENDIX E

METRIC CONVERSIONS

The following dimensions used in this report are shown with equivalent metric values:

	English	*Metric*
Floor-level door	32 x 72 in	81 x 183 cm
Overwing exit	20 x 36 in	51 x 91 cm
stepup	20 in	51 cm
stepdown	27 in	69 cm
Aisle width	15 in	38 cm
Seat pitch	34 in	86 cm
Seat row clearance	12 in	30 cm
Seat 1 exit path (Figure 5)	4 ft 9 in	145 cm
Seat 2 exit path	29 ft 2 in	8.9 m
Seat 3 exit path	13 ft 3 in	4.0 m
Seat 2 aisle to exit distance	*18 ft*	*4.6 m*
Subject weights	105 lb	47.6 kg
	124 lb	56.2 kg
	150 lb	68.0 kg
	175 lb	79.4 kg
	200 lb	90.7 kg
Rates	1 ft/s	0.3 m/s

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